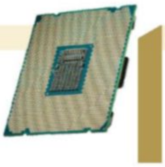

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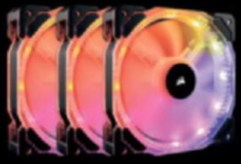

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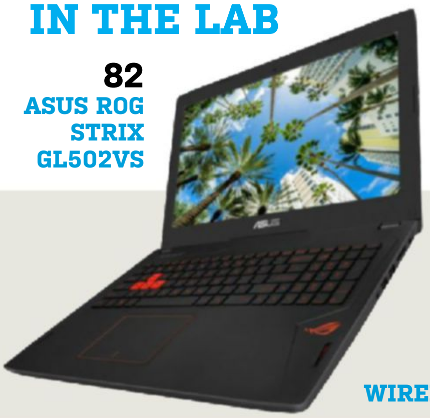

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Tuan
Nguyen

THE TRUE VALUE OF A PC IS MORE THAN ITS SPECS

I THOUGHT $699 WAS CHEAP. I was wrong. Several issues ago, we attempted to build a respectable computer without going above the $699 barrier, and that was already a feat in itself. But after much deliberation and wrangling, we decided that we could do even better: Try $599.

The rules were simple. We had to reduce the price of the system, but not drastically have it take a performance hit. This was no easy task. Take it from me—I've never built a PC that was less than $1,000, even though I've tried. It's easy to go high-cost, but it's a challenge to set a budget and stick with it.

Back in the day, I built a "home" PC that had an external fiber-channel RAID array, with a very expensive Adaptec fiber-channel host adapter. The array itself housed five Seagate Cheetah fiber-channel drives, which I think cost something along the lines of $800 per drive. Basically, it was excessive, and required a lot of maintenance to keep things running smoothly. But, to be honest, looking back, I don't think it actually improved my PC experience at all. In fact, all the setup, maintenance, and troubleshooting actually degraded my entire experience.

Building a simple system often gave me a better overall experience, if I recount all the times that I built my own machine. The more complicated the hardware setup, the more problems I had to deal with, and the more time I had to spend figuring things out when something went wrong. And things can and will go wrong. It's just the nature of the beast. Another thing that's worth considering is that components are so good these days. Even the value-ended offerings in the CPU and GPU categories are seriously powerful. You get a lot for your money, and we have to thank great strides in CPU and GPU architecture design for that. If you don't game much on your PC, or at all, your money goes even further. I'm certain our new $599 system will pummel the insane system I had back then, fiber-channel and all.

Looking at the whole ecosystem now, I think that the total user experience is more important than specifications alone. Now I build what I need, not necessarily what I want. I look at my computer use case a lot more carefully, even though my income today is much better than it was 15 years ago. Sure, it's fun to gawk at crazy specs, but one should weigh up all the factors.

Most of the time, I'm using my desktop to work and do productive things. I don't game much at all. So, you can see how the ultra-budget system builds are attractive for me. Just in case I do play a game or two, though, I'll consider that GTX 1080 Ti—for safe measure.

Tuan Nguyen *is* Maximum PC*'s editor-in-chief, also known as "the pointy end of the stick." He's been writing, marketing, and raising hell in the tech industry for 20 years.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Xbox Goes 4K

Microsoft has the world's most powerful console

Microsoft's Xbox One X isn't a new system, but a hardware upgrade that means the Xbox can now tick the 4K checkbox. It's also backward compatible with a huge library of Xbox games.

ON NOVEMBER 7, you'll be able to swap $499 for what Microsoft proudly claims to be the world's most powerful console: the Xbox One X, previously known as Project Scorpio. And yes, the name is a little clumsy. The headline is enough power for full 60fps 4K gaming. The sleek black box packs a custom 2.3GHz eight-core processor, a 40 Compute Unit AMD GPU, and 12GB of GDDR5. Plus, there's 1TB of storage and a UHD drive. A decent, if not spectacular, hardware upgrade. And that's what this is: not a new system as such, but an Xbox One with more oomph.

The One X is twice the price of a One S, and basically plays the same games, 35 of which will get free 4K upgrades. *Minecraft* looks lush (if you've never played with high-res texture packs and shaders on your PC). So, will people shell out the extra for the enhanced experience? You'll need a 4K screen, of course, although clever supersampling technology will make the most of a 1080p screen. The Xbox S can play 4K Blu-rays and run games upscaled to 4K and in HDR already. 4K can undoubtedly look stunning, but HDR may prove to be just as important. 4K can be subtle in a way that HDR isn't—it pops.

What would help the One X is some exclusive games. Sony understands this better, and has top titles that are PS4 only. Sticking to the Xbox One doesn't mean you'll miss out on the next chapter of the big game franchises, you just won't get them in 4K. This makes it look like an expensive upgrade if you already have an Xbox One.

What's missing from this picture? Any talk of VR. Despite Microsoft's considerable investments in the technology, it quietly dropped all mention of it at the One X launch. It will come to the One X at some point—so says Xbox's head honcho, Phil Spencer. You'll have to wait, though. Hints have been made that any such system will be wireless. Despite media interest and the proliferation of systems, VR has yet to make any real impact. Sony's PS4 VR kit has not made much headway—even shifting a million headsets, that still represents under 2 percent of its PS4 sales.

One pleasing development are the plans by Mr Spencer to bring more Xbox One games to the PC, along with Game Pass. Xbox 360 games are a trickier proposition, as the machine didn't run x86 hardware. Game Pass would be welcome, but it'll need a decent PC-compatible library to go with it. One thing we would like to see on the Xbox itself is keyboard and mouse support. It's been talked about for years, but never seems to arrive. It can't be that difficult to implement, surely?

The console market is a tough and notoriously fickle one. Sony's PS4 is doing rather nicely—about 60 million shifted so far. The Xbox One has yet to manage half that number. If you just want 4K, the PS4 is $100 cheaper. Still, the One X looks cool, has a big library of games, and, hey, it is the world's most powerful console. **–CL**

> “The One X is twice the price of the One S, and plays the same games.

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Happier times: Putin meets with President Obama in NYC, September 29, 2015.

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TWICE AS MANY states as originally feared were hit in the attack on the electoral system during the last election, according to a leaked NSA document. Most intrusions attempted to steal data and potentially embarrassing emails; however, in Illinois, hackers tried to alter voter data, but failed. Thankfully, a full attempt at disruption wasn't attempted, either through lack of access, fear of reprisals, or because it was designed as an intelligence-gathering hack. Investigations were hampered by the fact that federal authorities had no jurisdiction over state electoral systems. That has been addressed, and the electoral system has now been designated a national critical infrastructure, giving greater power to inspect and intervene in state systems.

The interference highlights vulnerabilities in the electoral system, currently a patchwork of disparate technologies. Democracy stands or falls on the integrity of the electoral process, and if anything deserves the tightest security, this must be it. In three years' time, the hackers may well be back. **–CL**

MOST POWERFUL APPLE YET

APPLE'S ANNUAL developer conference, WWDC, brought a slew of updates, new hardware, and a very long keynote speech. We got the iPad Pro, watchOS 4, Siri-powered HomePod, and myriad hardware and software upgrades, including beefier hardware on just about every Mac. But what many came to see was the iMac Pro. It looks fantastic, packs some delicious hardware, and is also majestically expensive.

Creative types have been complaining that their shiny Macs have fallen behind PCs. The company is seen as concentrating too much on the iPhone and iPad, and not enough on its desktops. The workstation market is growing, too, up over 20 percent in three months. The Mac Pro hasn't been updated much since 2013, and is struggling. A new modular version won't arrive until next year at the earliest. The iMac Pro will be Apple's most powerful machine for now.

The iMac Pro certainly looks the part. Inside, it's a Xeon-based machine with 8, 10, or 18 cores, coupled with 32–128GB of EEC RAM, a tasty Radeon Pro Vega GPU, 10Gb Ethernet, and a 27-inch 5K screen. Prices start at $4,999 and climb rapidly, due to the "Apple tax"–expect well over $10,000 if you go high-end. The upgraded iMacs are available now; for the delicious iMac Pro, you'll have to wait until December. **–CL**

INTEL MAKES US WAIT

Top new Core i9 chips still months away

intel
CORE i9
X-series

A LITTLE WHILE BACK, we were all ready and excited about AMD's official announcement of Threadripper, its 16-core monster processor, when along comes Intel and announces it was going to 18 cores with its new Core i9 line. It transpires this was a little bit of gamesmanship by Intel to undercut AMD's reveal. Release of the new Skylake-X Core i9 chips is to be staggered over several months, and it is going to start at the bottom, and work upward. This means the juicy 14, 16, and 18-core versions won't be here until October.

This leaves AMD's massive Threadripper—the chip and socket are huge—as the top multicore chip for the summer at least. Widely called the Ryzen 9, it was notable that, at Computex, it was called Threadripper only. AMD's James Prior (four-word job title) went as far as to correct somebody via Twitter on the fact. So, Threadripper it is—12 and 16-core versions will be out and about in July. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

AUTONOMOUS DRIVING
Audi has shown its forthcoming new A8 parking itself in a garage without the driver being in the car.

EAT YOUR WORDS
Been sent a nasty message? A New York bakery will send the troll a lovely cake with their words iced on to it.

WI-FI AS STANDARD
Wireless is now seen as part of a house's infrastructure—Wi-Fi Certified homes will ensure there are no deadspots.

TRAGEDIES

UBER LOSES BOSS
Troubled CEO Travis Kalanick is to take an indefinite leave of absence after a damming report on the Uber workplace culture.

WEBSITE WINDOWS BSOD
A bug enables any site to slow and crash a Win 7, 8, or Vista machine just by visiting the page.

$100 MILLION CRASH
An engineer caused a power surge at a British Airways data center, leaving 75,000 people stranded around the world.

Jarred Walton

TECH TALK

The PCIe lanes conundrum

WHEN PCI EXPRESS first started to replace AGP and PCI slots in 2003, most motherboards only included a single x16 slot, and maybe one or two x1 slots. Back then, it really didn't matter, because most PCs only needed the new interface for the graphics card. It took a while before audio, network, USB 3.0, and other standards would really start to utilize the standard, but over a decade later, PCIe has become ubiquitous.

The problem is, many PCs are severely lacking in the PCIe lanes department—and it's largely Intel's fault.

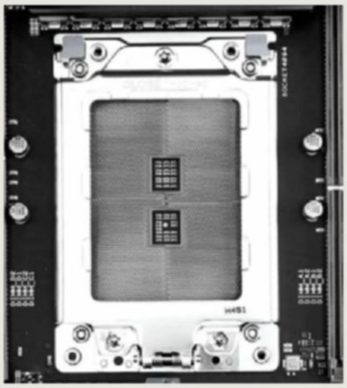
Starting in 2009, with socket LGA1156, Intel moved the fastest PCIe lanes directly on to the CPU package. Eight years ago, we had 16 PCIe 2.0 lanes on Intel's Lynnfield (first-gen Core) processors, and for the mainstream platform, that's where we've stayed. Doubling the bandwidth per lane going from PCIe 2.0 to PCIe 3.0 helped curb our need for more lanes, but we're fast running into bottlenecks.

Consider a reasonably high-end PC, with a fast GPU and NVMe storage. The graphics card still gets the 16 PCIe lanes from the CPU, but the NVMe SSD shares bandwidth with networking, audio, USB, and more. Multiple NVMe drives can sit off the chipset, which provides 20/24 PCIe lanes for Z170/Z270, but the chipset still talks to the CPU over a DMI 3.0 link (equivalent to x4 PCIe Gen3). And the fastest NVMe drives can saturate the DMI link with a single drive.

You want faster PCIe-based storage? Intel has its enthusiast X99 and X299 platforms, where a single CPU can provide up to 40/44 PCIe lanes. But that "up to" just got a lot messier with Skylake-X and Kaby Lake-X, where the latter is basically just a Kaby Lake die slapped into a larger package. So, Kaby Lake-X gets you the same 16 PCIe lanes and dual-channel memory controller—and some of the PCIe slots on X299 mobos may not work with Kaby Lake-X. Ugh.

Here's where I start to get angry. We already had the arbitrary limitation of 28 PCIe lanes on the entry-level enthusiast processors, such as the i7-5820K and i7-6800K, which are still potent six-core processors. Pay an extra $150 for the i7-5930K or i7-6850K, and you get the fully enabled 40 PCIe lanes. Skylake-X bumps that up to 44—but only if you spring for a Core i9 part. The six-core i7-7800X and eight-core i7-7820X are both 28 PCIe lane parts. That means you can't do dual x16 graphics cards in SLI or CrossFire unless you buy a $1,000-plus processor, at least on the Intel side of the fence.

> “You can't do dual x16 graphics cards in SLI or CrossFire unless you buy a $1,000-plus processor.



AMD's socket TR4 for Threadripper is absolutely massive, with 4,094 pins.

Thank goodness for AMD, where not only do we have $300 eight-core processors that don't suck, but we'll soon get Ryzen Threadripper with up to 16 cores. The socket TR4 for Threadripper is insanely huge, as it's a repurposed socket SP3 that supports up to 32-core Epyc processors. The socket supports eight-channel memory, and 128 PCIe lanes with Epyc, but Threadripper will have to get by with "only" half the lanes and memory channels. The good news is that AMD says all the Threadripper parts will include a full 64 PCIe lanes.

Of course, both Threadripper and Skylake-X are geared for enthusiasts and professionals. If you're running a mainstream Ryzen or Intel Core CPU, you're stuck with 16 lanes on Intel and 24 on AMD, plus additional PCIe lanes from the chipset. Why does that matter? For a lot of us, it doesn't, but multiple GPUs and/or M.2 SSDs can hit bottlenecks. There are also professional workloads (such as machine learning) where having the additional bandwidth is beneficial.

For typical consumers, you can ignore all the hubbub about PCIe lanes, and run your single graphics card and maybe an M.2 SSD just fine. But if you're looking to build a personal Dream Machine? Don't get caught with insufficient PCIe lanes. Or wait for PCI Express 4.0, which doubles the bandwidth per lane of PCIe 3.0—and preliminary specs for PCIe 5.0 are also out, penciled in for 2019 with up to 4GB/s per lane.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

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Alex Campbell

OPEN SOURCE

Gaming on Windows on Linux Ain't So Bad

USING LINUX has always meant being a second-class citizen for gaming. But if you're up to the task, you can have the best of both Linux and Windows worlds.

A Windows virtual machine guest runs *Kerbal Space Program* on Linux.

It sounds crazy, the idea of running Windows under Linux. If I've learned one thing from being a Linux user, though, it's that I will go through extraordinary steps to play games. For me, being at the mercy of devs who may or may not port their games to Linux on Steam is infuriating. Running Windows games and applications in WINE is a nightmarish experience, full of half-implemented DLLs and missing functionality. And dual-booting my system just for the sake of games is always a pain in the ass.

My answer seemed to lie in the use of virtualization, though my previous experience using VirtualBox and VMWare Player has meant no GPU. After reading up on Linux's built-in virtualization software KVM, I took the plunge, and banished Windows from the bare metal, and installed Linux on my precious high-end desktop.

And it was good. Once I got it working, using KVM to boot a virtualized Windows machine made me ask myself why I hadn't done this before. By using KVM and the package qemu, I was able to pass a GTX 980 Ti through to the guest OS (Windows). The guest OS could then treat the GPU as though it were bare metal, and the Nvidia drivers were none the wiser. And performance is nearly on a par with bare metal.

If you're interested in doing this voodoo yourself, the Arch Linux wiki (https://wiki.archlinux.org/index.php/PCI_passthrough_via_OVMF) has a great article on how to set up qemu/KVM with PCI pass-through. Although qemu/KVM works pretty well, there are a few caveats that you should know about going in.

The first thing you need to understand is that qemu is basically a virtualized firmware. Unlike installing Windows on the bare metal of a motherboard such as MSI or Gigabyte, the OS sees the hardware as qemu. The bad thing is that qemu doesn't offer any support for SLI.

The second thing to know is that you need a newer CPU to pull this off. You need both a CPU and motherboard that support VT-d (Intel) or AMD-Vi. Your motherboard also needs to have IOMMU support enabled. And because you'll be running a VM, be sure to have enough RAM to run both your Linux desktop and your Windows VM.

You need at least two GPUs, as well. Before you're able to pass a GPU to the VM, you have to tell Linux to blacklist a specific hardware address before the Nvidia or Radeon driver can bind to it. This can be tricky if you have two of the same GPUs, because they have similar hardware IDs, and each card has both an audio and video device. That said, you can mix and match GPUs from different vendors if you dedicate one to the VM and one to the host. If you have a CPU that has an onboard GPU, you can use the CPU's graphics to drive your Linux desktop, while using your PCIe device for your Windows VM.

Once you blacklist it, Linux can't use the GPU you've designated for the VM. As a symptom of this, each GPU needs to attach to your monitor(s) separately. If you only have one monitor, it means that to switch to your Windows VM, you have to switch inputs on your monitor. You also have to keep a separate keyboard and mouse or a KVM switch handy.

As with anything Linux, getting a GPU passed through to Windows running in a VM can be a bit of a project. But if you prefer Linux, and just can't let go of your Windows games, it is definitely a project worth the effort.

Alex Campbell is a Linux geek who enjoys learning about computer security.

THE LIST

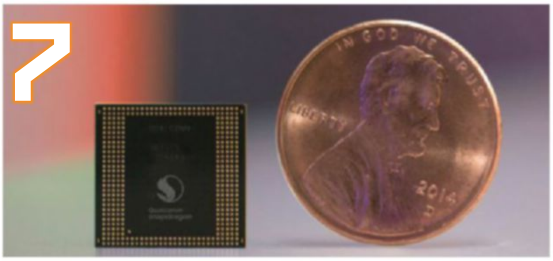
TOP 8 COMPUTEX 2017 HIGHS

8

COOLER MASTER MASTERKEYS MK750

A mechanical deck with 32-bit ARM Cortex M3 processor for adjusting RGB effects without drivers? That's neat.

7



SNAPDRAGON 835

Qualcomm's mobile architecture will soon power passive-cooled, always-connected PCs running Win 10.

6

MSI GT75VR

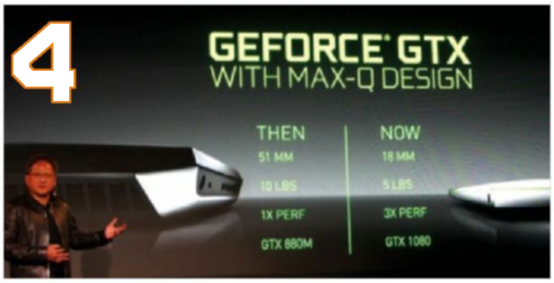
A desktop replacement laptop showcasing portable innovation: a mechanical keyboard, overclockable CPU and GPU, and a 120MHz almost-HDR TN screen.

5

ASUS ROG ZEPHYRUS

Max-Q was in action in this 0.7-inch-thick laptop, packing a full GTX 1080 into an impossibly slimline body.

4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NVIDIA MAX-Q Nvidia's electronics wizardry reaches sorcerous levels as it squeezes its GPU architecture into a super-thin, extra-efficient package.

3

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A line of fully customizable vertical cases with 30-liter capacity, room for water cooling, and a footprint not much larger than a graphics card.

2

INTEL CORE I9

Intel launched its X-series CPUs, including the 'Ripper-taunting i9: It's due up to 18 cores and 36 threads, but expect "enthusiast" pricing.

intel
CORE i9
X-series

1

RYZEN
THREADRIPPER
AMD

AMD THREADRIPPER More on AMD's forthcoming Ryzen 9 CPU emerged: It'll have 16 cores, 32 (totally ripped) threads, and 64 PCIe 3.0 lanes.

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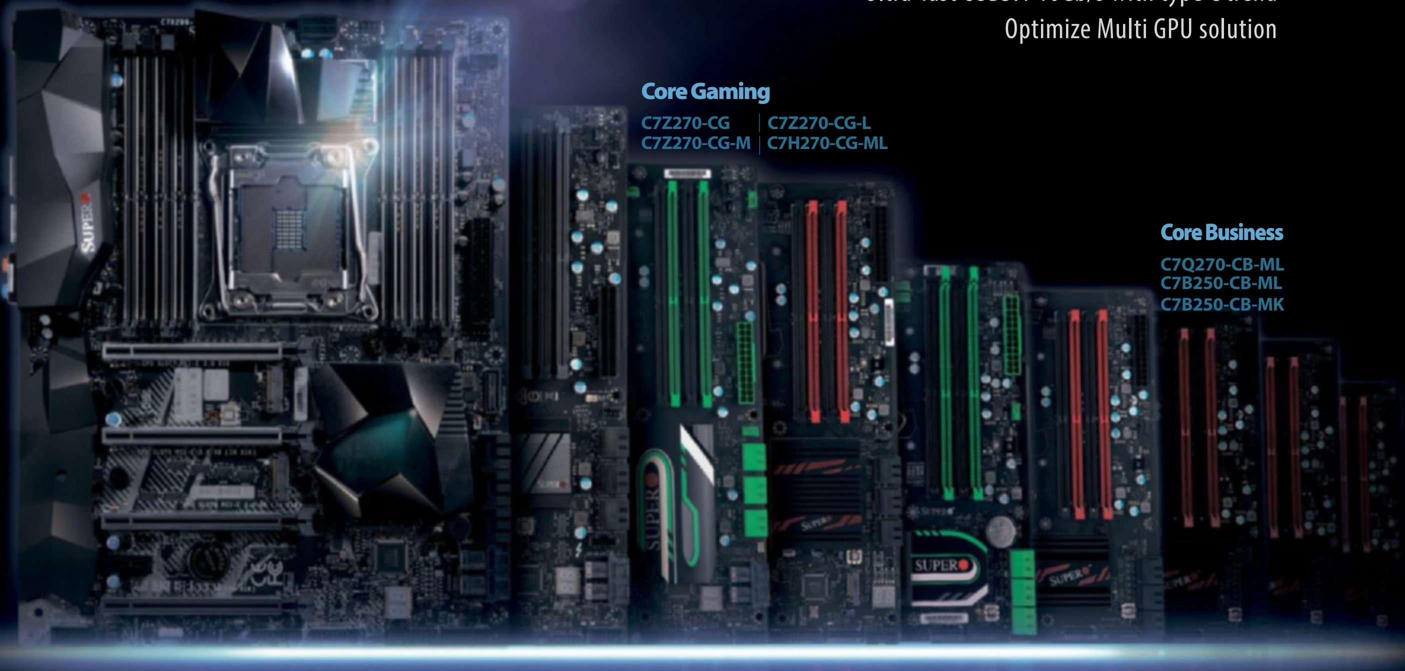

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HEAD TO

BY **JEREMY LAIRD**

X86 vs. ARM

Microsoft is at it again, rolling out an ARM-compatible version of Windows, this time with emulation capabilities to support legacy 32-bit x86 apps. How well that emulation works remains to be seen. But it begs the age-old question of how the rival CPU architectures compare, and what the future holds. Are ARM chips still the choice for mobile efficiency? Is x86 still the obvious performance play? Will the swarm of ARM chip makers devour every form factor currently dominated by x86? Or can Intel finally make a successful phone chip?

ROUND 1

RISC vs. CISC

Remember when RISC versus CISC was the battle of the ages? Even today, Intel's chips and the upstart battalions of ARM processors align according to this paradigm, with x86 CPUs still CISC (or complex instruction set computing), and ARM representing the vanguard of RISC (or reduced instruction set computing).

But, in practice, it's a moot point. That's because ever since the Pentium Pro (and indeed AMD's K5), x86 processors have really been RISC chips internally, and have relied upon a microcode translation layer to handle the x86 CISC instruction set. What's more, over time, x86 coding has coalesced around a relatively small number of commonly used instructions. All of which means that the old divides that saw x86 chips require relatively complex compilers, along with complex instruction scheduling and decoding hardware, and thus a higher transistor count for a given theoretical performance capability, not to mention limitations on instruction pipelining, no longer fully apply. CISC architectures, such as ARM, have likewise become more complex, with support for floating point math, virtualization, and hardware cryptography. In short, RISC versus CISC is no longer the crucial question.

Winner:
It simply doesn't matter

ROUND 2

Pure Performance

If RISC versus CISC is no longer a crucial metric, there is still a divide between x86 and ARM that maps to similar territory: x86 remains a relatively complex instruction set; ARM relatively simple.

Take ARMv8, the latest ARM instruction set. All ARMv8 instructions are 32-bit (unless in 16-bit thumb mode), and with that comes the usual trade-off of fixed-length instruction encoding. On the other hand, x86 has variable length instructions, and supports anywhere from 8 to 120 bits.

So, x86 decoders are relatively big and complex, ARM decoders small and simple. That means x86 has an inherent advantage in terms of instruction density, while an arguably "purer" CISC architecture like ARM runs up against instruction-dependent limitations when it comes to optimizations pertaining to pipelining and parallelization.

In the end, it's complexity versus simplicity, and complexity wins in the pure performance stakes, provided you have sufficient transistors and power. In a modern desktop or server context, where transistor counts now measure in billions, and supplying ongoing power isn't a fundamental limitation, x86 still has a clear performance advantage.

Winner:
x86, for now

ROUND 3

Mobile Performance

What's good for x86's goose is also good for ARM's gander. By that we mean that very much the same attributes and qualities that give x86 CPUs the edge in terms of pure performance play to ARM's strengths as a mobile processor.

Admittedly, x86 and ARM have converged quite dramatically. If you compare the likes of, say, Apple's recent CPU cores (in iPads and iPhones) with those of Intel, they look remarkably similar from the proverbial 1,000 feet.

Thus, whether it's x86 or ARM, you'll see the boxes alongside out-of-order execution, 64-bit memory addressing, and even 6-wide instruction issuing checked for both architectures. What's more, in the real world, if you compare, for instance, the first Apple iPad Pro, with its dual-core ARM processor, to a 12-inch super-thin MacBook, and its dual-core x86 chip, you'll find they trade blows in basic performance metrics.

Remember, however, that this particular comparison is at the margins where x86 and ARM overlap—the most powerful ARM architecture versus the weakest full-power Intel Core chip. The more mobility you require, the more ARM's fundamental simplicity gives a power efficiency advantage.

Winner:
ARM, with efficient ease

HEAD

For pure performance, x86 has a clear edge.

Apple's latest ARM chips are more comparable to Intel's Core M processors.

ROUND 4

Software Support

Much of this comes down to what kind of software you run. In theory, pretty much any app can be coded for either architecture. However, there are differences that give x86 an advantage.

For starters, part of the complexity of x86 includes support for instruction extensions that improve performance in certain workloads. We're dealing here with that middle ground between true general-purpose processing and fixed-function hardware accelerators.

Adding a small fixed-function engine to an ARM SoC, perhaps for video decoding, is simple. But the added complexity and transistor count of x86 processors allows for the addition of programmable vector instruction sets, such as MMX and AVX, that can be used for a broad range of workloads. It makes x86 more flexible for extracting a lot of performance from a wide range of code.

Support for legacy code is another x86 advantage. All x86 chips must support the original 16-bit registers and instructions. ARMv8 architectures, on the other hand, only support ARMv7 or AArch32 code across exception boundaries. Simply put, not only is there more existing x86 code to choose from, but x86 runs old code faster and better.

Winner:
It's x86's greatest strength

ROUND 5

Future Dominance

As things stand, neither x86 nor ARM dominates the whole landscape. For power, x86 has the edge, for efficiency and portability, ARM is the obvious choice. But will it always be this way?

For a while, it looked as though Intel wanted to insert x86 into every form factor and application. It created the Atom processor to take on ARM in phones and other ultramobile devices. Meanwhile, ARM chip makers, such as Qualcomm, have been increasing pure processing power, and even creating products for server computers. Indeed, Microsoft ported Windows Server for ARM architectures, though it hasn't yet been released for retail, and it's having a second crack at supporting client ARM machines with a Windows OS.

That said, Intel has pulled out of the phone market, and narrowed its ambitions for Atom to high-performance tablet PCs. And ARM's server strategy is far from proven, as are ARM client PCs. Who would have guessed that Intel would fail so miserably in its efforts to move into ARM's territory? For the foreseeable future, the built-in advantages of x86 and ARM will make them very hard to budge from their respective strongholds.

Winner:
A small edge to ARM

And the Winner Is...

In the short to medium term, x86 remains the obvious pick for performance computing, while ARM is the easy mobility option. The further out you look, however, the less certain those assumptions seem. On the one hand, thanks to AMD's recent revitalization with the new Ryzen processor, the x86 landscape suddenly looks lively once more. Indeed, as we go to press, Intel has revealed a whole new range of Core i9 chips with up to 18 CPU cores. That's a little bit crazy and a whole lot exciting. On the other, you could argue that it's a blip that goes against the general trend for more innovation and growth in the ARM market. What's more, thanks to ARM's more open approach to licensing, there are far more companies creating ARM-based CPUs and SoCs than the mere pairing of Intel and AMD on the x86 side of the equation. In the very long run, then, the inevitable encroachment of ARM on traditional x86 territory seems irresistible. But for fans of high-performance personal computing, x86 will be the architecture of choice for a very long time to come. ⏻

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Upgrading Time
> Size Issues
> Docking Dilemmas

Time to Upgrade?

Doc, thank you and the team for many years of PC news. I've been a faithful subscriber since the days of *Boot*.

In 2012, I built my dream system using an Asus P8Z68-V Pro/Gen3 mobo, Intel Core i7-3770K CPU, Cooler Master Hyper 212 cooler, 8GB Crucial Ballistix DDR3-1866 memory kit, GeForce GTX 680, 128GB Crucial m4 SSD, and two 1TB WD Caviar hard drives in a Cooler Master HAF 922 case. I also had an HP Pavilion w2408h monitor, running at its 1920x1200 native resolution. I upgraded the video card a couple of times, and currently have a GeForce GTX 1080 Ti Founders Edition, which I bought because my GTX 980 was choking on *Mass Effect: Andromeda's* highest settings. I also swapped the memory out for a 16GB DDR3-1866 kit, upgrading to Windows 10 in the process.

Most of my PC time involves gaming (*World of Warships*, *Mass Effect*, and *Ghost Recon Wildlands*), but I also use it for the web, a little video editing, *Word*, *Excel*, and so on.

It seems like my PC should be getting long in the tooth, but you frequently mention incremental improvements to Intel's microarchitectures. Would I see much benefit from moving to LGA 1151 and a Core i7-7700K? Or is there anything you'd change about my setup to improve performance and extend its life without breaking the bank?

GTX 1080
GEFORCE GTX

Power connectors on GeForce and Radeon cards can interfere with non-standard cases.

Right now, I can play *Mass Effect* using the Ultra preset without a hiccup. And with everything maxed out in *Rise of the Tomb Raider* and *Ghost Recon*, I see benchmark results in the 60fps range. My only real gripe is that games load slowly since they're on my hard drives. Thus, I've been considering Crucial's 1TB MX300. **–BJ Koho**

THE DOCTOR RESPONDS: Really, every architecture since Sandy Bridge has been incremental, improving performance modestly through higher clock rates and greater instruction-per-cycle throughput. The jump from your Ivy Bridge-based 3770K to a 7700K would be noticeable, particularly under taxing workloads like video rendering. However, games and lightly-threaded apps probably aren't bottlenecked severely by your host processor. Holding off on a new platform saves you the cost of a motherboard, CPU, and DDR4 memory kit. There are more effective subsystems to spend money on.

In fact, you already identified the prime candidate for an upgrade: that 128GB SSD, which leaves you way short on capacity. Ideally, the OS, games, and apps live on solid-state storage, while music, movies, pictures, and documents move to mechanical disk. The Doc achieves this with two 512GB Crucial m4s in his workstation (also based on a Core i7-3770K). Splurging on a 1TB drive should create room for lots of games. And if those WD Caviars aren't configured in a mirrored array, the Doc hopes you're backing up important files in a way that protects against hardware failure.

As for gaming, consider investing in a new monitor. Nvidia's GeForce GTX 1080 Ti is capable of smooth frame rates at 3840x2160, providing you dial in your quality settings. Naturally, it cuts through 2560x1440 with ease. A G-sync-capable QHD display would have a more profound effect than any other component.

Size Issues

Hi Doc. I'm a long-time reader, and I have a problem with my new video card: it doesn't fit in my case!

I own a Dell Precision Tower Workstation (T7910) that's mostly used for compiling C++ code. But I also like to play games. I purchased Zotac's GeForce GTX 1070 Mini 8GB to drive two Dell 27-inch monitors (2560x1440). The card fits fine, though just barely. However, the eight-pin power connector faces the top, which prevents

↘ submit your questions to: doctor@maximumpc.com

USB-C enables high-performance docking stations for gaming laptops.

me from closing my side panel. Can you recommend something capable of equivalent performance that might fit better? I also need two full-sized DisplayPort outputs. **–Scott Moore**

THE DOCTOR RESPONDS: Dell's atypical chassis layout is definitely optimized for workstation-class graphics cards. If you take a look at the T7910's list of add-in boards, it's loaded with FirePro and Quadro options, all of which sport rear-facing auxiliary power connectors. There's not a single GeForce or Radeon.

Unfortunately, every GeForce GTX 1070 in the Doc's lab has its power connector facing the same way as your Zotac card, and an informal polling of Nvidia partners suggests that other 1070s are configured similarly. According to the Doc's sources at Nvidia, the company started designing enthusiast-oriented cards with top-facing connectors a couple of generations back in response to customer feedback, so that's what you'll find today.

This doesn't leave you with easy solutions, though. EVGA sells an adapter it calls PowerLink, which reroutes top-facing power connectors to the back of compatible cards for cable management purposes. However, PowerLink still requires clearance above the frame that doesn't appear to be available in your chassis.

You could go the Quadro route. Many professional applications are built with DirectX in mind. So, even workstation-class cards end up gaming well. Their downside is a hefty price premium. Expect to pay around $2,000 for a Quadro P5000 in the same league as Nvidia's GeForce GTX 1080. At the spectrum's opposite end, you could tuck the workstation into a corner where its open side panel doesn't show. There's always the option of going back to whatever card you purchased the workstation with. Or, find a new chassis for all of Dell's hardware.

Readers Helping Out

Good morning Doc. In response to Gordon's letter in the May issue, it sounds like he really wants to run Windows 7 using his motherboard's UEFI mode instead of the legacy BIOS in order to solve some hardware compatibility issues. It is possible, but not easy.

First, he needs the 64-bit version of Windows 7. The 32-bit version will not work.

Second, he needs to install Windows 7 from a USB stick formatted as FAT32, not NTFS. The official Microsoft DVD-to-USB tool will not work because it formats the drive as NTFS. There are many recipes on the web for building a bootable, FAT32-formatted stick. Or, if he is still rocking an optical drive, he can install from the original Windows 7 DVD. But he needs to make sure the boot device is set to "UEFI optical drive" in his firmware, not "legacy optical drive." He will know he got it right when the installer offers to convert his hard disk to GUID partition tables, rather than Master Boot Record. **–Stephen Lardieri**

THE DOCTOR RESPONDS: Thanks for the contribution, Stephen. If Gordon is willing to stick with Microsoft, getting his copy of Windows 7 running on a UEFI-compatible platform could solve issues with his 24-drive storage system. He didn't mention if his frustrations were related to trying to boot from a 2TB-plus disk or create more than four primary partitions. We also don't know if he owns the 64-bit version of his OS. But if Gordon's setup satisfies a handful of requisites, your guidance might save him the time investment needed to learn Linux or FreeBSD.

Read this TechNet article for more on how to make Win 7 and your UEFI-based PC play nice: http://goo.gl/VsHzig.

Dock at Your Own Risk

I'm about to move from a house to an apartment, and decided to switch from a bulky desktop to a gaming laptop. I'm interested in buying a docking station to go with my new machine, and I've noticed several USB 3.0-compatible docks on the market.

What will I sacrifice if I connect CAT5, DisplayPort, and headphone/mic cables to the docking station instead of to the laptop directly? Does USB 3.0 bottleneck Gigabit Ethernet and DisplayPort? Will I give up gaming performance?

I'd like recommendations on the docking station, too, preferably under $120. **–Winston Cheng**

THE DOCTOR RESPONDS: When it comes to docking stations, pay attention to the specs.

Case in point: Amazon's best-seller supports multiple monitors, Gigabit Ethernet, audio, and multiple USB ports. But read the fine print: It only allows 2560x1440 via HDMI, and if you hook up two screens, it drops to 1920x1200. Even at QHD, the best you could get is a 50Hz refresh. Not surprisingly, the manufacturer recommends against using it for gaming.

StarTech's USB3VDOCK4DP seemingly comes closer to what you need. It lists for almost $160, but can be found online for less. A single DisplayPort output facilitates up to 3840x2160 at 30Hz, Gigabit Ethernet won't be bottlenecked over its 5Gb/s USB 3.0 interface, audio is transferred over a 3.5mm mini-jack, and plenty of USB 3.0 ports take peripheral hook-ups, too.

Here's the thing, though: A 30Hz refresh rate, even at 2560x1440, isn't great for gaming. DisplayLink's DL-5700 chipset, at the heart of StarTech's docking station, doesn't do 60Hz until you hit 1920x1080. Even then, DisplayLink concedes that the USB3VDOCK4DP is meant for productivity, not fast-paced fragging.

That leaves you looking at more expensive options based on USB-C or Thunderbolt 3. Kensington's $180 SD4500, for instance, takes a USB-C input from your laptop and exposes HDMI/DisplayPort outputs at up to 4096x2160, three USB 3.1 Gen 1 ports, and one USB-C port for peripherals, Gigabit Ethernet, and 3.5mm headphone-out/mic-in jacks.

Conceptually, the 5Gb/s device offers plenty of throughput for high-performance transfers, and Kensington's implementation leverages the protocol's Alternate Mode Functional Extension to enable a native DisplayPort signal over USB-C. That means circumventing the limitations of those lower-cost docking stations based on USB 3.0. But taking advantage of this relatively new technology also requires a gaming laptop with USB-C connectivity, explicit support for DisplayPort over USB-C, and Windows 8.1/10. Keep that in mind as you shop for a desktop replacement.

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BUILD A KICK-ASS BUDGET GAMING PC

ADVANCES IN TECHNOLOGY AREN'T LIMITED TO THE HIGH END, AS THIS $599 MACHINE PROVES

BY ALAN DEXTER

EVGA
GEFORCE GTX 1050 Ti

FOR ALL TOO MANY OF US, the *Maximum PC* Dream Machine remains just that: a dream. The hang-the-cost attitude has made for some incredible systems, and this year's will be no different, but what if cost is a factor? What if you can't afford to drop north of a grand on the cooling system alone? What if you want a machine that costs a fraction of what we dream up every year? What if you want a system that's as pleasing to your pocket as it is to use?

Our budget machine aims to offer just that: an impressive all-around experience for a fraction of what we normally look at in these pages. As the title suggests, that includes being able to handle games as well. Think of it as a console that you can actually do useful things on, as well as keeping yourself entertained. It is a PC, after all. And if you have a bit more cash to hand, you can use this system as a starting point for something that answers your needs much more specifically.

A quick note: When we built our budget machine a year ago, it had the subtext of being a powerful ally for VR as well, which you'll find lacking from the sales pitch of this year's budget machine. That is simply because VR isn't quite the driving force that it was. You can still play VR games on this setup, although if you're seriously into VR gaming, you may want to upgrade the graphics card.

INGREDIENTS

PART		PRICE
CPU	Pentium G4600	$87
Motherboard	Asus ROG Strix B250I Gaming	$109
RAM	Patriot Viper 4 Series 8GB (2x 4GB) DDR4-2400	$63
OS Storage	Kingston UV400 120GB	$56
Data Storage	Seagate BarraCuda 1TB	$49
GPU	EVGA GeForce GTX 1050 Ti 4GB ACX 2.0	$130
Case	Phanteks Enthoo Evolv ITX	$55
PSU	Corsair CX550	$50
TOTAL		$599

Prices correct at the time of going to press.

CPU

INTEL PENTIUM G4600 $87

WHEN WE SET OUT to build our budget machine a year ago, we turned to AMD for the brains of the operation. Given that we set ourselves an even tighter overall system price this year, you would be forgiven for thinking that AMD would be an obvious choice this time around, too. However, it's actually Intel that holds our budget hearts right now. Its Pentium brand has been getting us hot under the collar for a while, and this G4600 manages to check a surprising number of our essential boxes, given its lowly price tag.

There are actually plenty of choices at the bottom of the processor market, with older AMD Semprons vying with Intel Celerons, starting from as little as $32. Such chips lack anything approaching real oomph, though, with low core counts and low, low operating frequencies holding your general computing experience on the back foot. In fact, it isn't until you get closer to the $100 price point that the silicon begins to deliver where we need it.

This quad-thread Kaby Lake chip (two physical cores) boasts a healthy operating frequency of 3.6GHz, crams the Intel HD Graphics 630 into its silicon, has 3MB of L3 cache, and a thermal design power of 51W. Obviously, we have no interest in using the integrated graphics, because we've budgeted for a discrete graphics card from the off, but it's always good to have a backup, in case anything goes wrong.

An important factor when choosing this chip is the inherent upgrade path on offer, thanks to the fact that it uses the LGA1151 socket, which means that, at a later date, you could drop in a Core i5 or even a Core i7 for a huge speed boost. The fact that the Pentium G4600 supports up to 64GB of DDR4-2400 memory gives you another upgrade option, too.

For now, at least, the Pentium family gets the nod for any budget build. But it shouldn't be long before we see AMD APUs coupling Ryzen brains with Vega brawn to power a completely different kind of budget gaming machine, so watch this space.

GPU

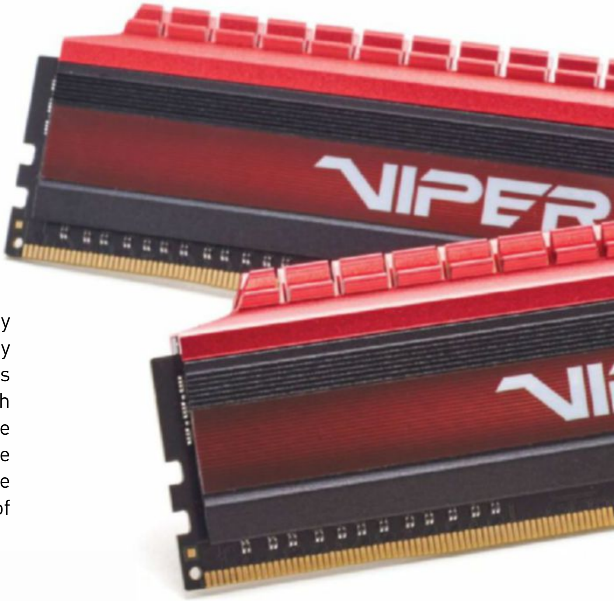
EVGA GEFORCE GTX 1050 TI 4GB ACX 2.0 $130

NOTHING TOUCHES graphics cards when it comes to choice. Even when you hone in on a particular GPU, you'll find there are multiple cards available, often from the same company. The graphics card market is now so granular that a few extra dollars here and there can net you a slightly higher overclock, a quieter cooler, or added bling in the form of pulsating LEDs. Whether you have $100 or $1,000, there's a graphics card out there for you.

Amazingly, if you're on a tight budget, there aren't too many GPUs worth considering: At the budget we've set aside for the graphics subsystem, this essentially comes down to a toss-up between the Nvidia GeForce GTX 1050 Ti and the AMD Radeon RX 560. This is a fairly straightforward win for Nvidia, because the 1050 Ti is a much stronger performer, and 4GB models are more readily available than their RX 560 siblings. AMD's Radeons seem to be suffering from renewed interest in cryptocurrency mining as well, making for limited stock pretty much everywhere.

The EVGA card we grabbed boasts a slight overclock over Nvidia's base specification—with a base clock of 1,354MHz against Nvidia's base specification of 1,290MHz. These days, the base clock is actually less important than the boost, because GPU Boost 2.0 automatically overclocks the card, dependent on temperature—but, again, this overclock extends there as well, with a boost clock of 1,468MHz against the suggested 1,392MHz. The single fan cooler does a great job of keeping those 768 CUDA cores chilled without making a lot of noise, as well.

The other benefits of this Pascal card are its short form factor and the fact that it doesn't need any additional power connectors, drawing all the juice it needs from the PCIe slot. Nvidia recommends you have at least a 300W PSU for any system using this card, which means we have power to spare in our rig.



RAM

PATRIOT VIPER 4 SERIES DDR4-2400 8GB (2X 4GB) $63

A YEAR AGO, you'd have been looking at 16GB of DDR4 for $60. Or, to put it another way, memory has doubled in price in the last 12 months. As we're working to a tight budget, there's no wiggle room to allow for the increase, so we have to get by with less.

That said, we still recommend using named brands when buying memory, and Patriot is a company that has served us well for many years. These red and black sticks sit comfortably at 2,400MHz, with 15-15-15-35 timings. The fins of the cooler don't extend too high above the PCB, so they shouldn't interfere with your CPU cooling method of choice either.

MOTHERBOARD

ASUS ROG STRIX B250I GAMING

$109

THIS MINI-ITX motherboard is tiny, so it must be lacking on the feature front, right? Wrong. While it does only have one PCIe x16 slot, it manages to cram six USB 3.0 and four SATA ports into its tiny form, boast integrated Wi-Fi, and include support for not one but two M.2 drives. Oh, and it lights up like a Christmas tree as well. Impressive—very, very impressive.

The integrated SupremeFX audio is a cut above as well, residing on its own shielded area of the motherboard to maintain signal integrity, and using Nichicon audio capacitors. Throw in the three PWM fan headers, and you have a fully featured motherboard that just so happens to be absolutely tiny.

OS STORAGE

KINGSTON SSDNOW UV400 120GB $56

IF WE HAD MORE cash, we'd populate one of the motherboard's M.2 slots, for some seriously fast storage. Unfortunately, M.2 drives still command a hefty premium, so your money is best spent on a standard SSD for the time being. If you're desperate for M.2, we recommend the 128GB Samsung SM961 for $90.

As with memory pricing, it's been a turbulent 12 months for SSDs, and this year's budget build appears to offer the same capacity as last year—but at an increased cost. However, the devil's in the details, and last year's 120GB V300 is a slower beast compared to this year's 120GB UV400. Peak read and writes jump from the previous drive's 450MB/s to 550MB/s and 500MB/s respectively, so you are getting a slightly better deal, depending how you look at it.

DATA STORAGE

SEAGATE BARRACUDA 1TB $49

SSDS ARE GREAT for speedy access, but they lag behind spinning drives when it comes to capacity. And when you're talking about building a games machine, having somewhere to save your games is important. Especially when your main boot drive is quite small, like we have in this machine.

This 1TB BarraCuda boasts 64MB of cache, to help keep your data moving, and while the maximum sustained transfer rate of 210MB/s isn't going to trouble an SSD, you've got enough room on the OS drive for your most-used apps and games. As a bonus, this single-platter, twin-head drive is slightly thinner than standard hard drives, which could potentially help with airflow in a super-tight system.

CASE

PHANTEKS ENTHOO EVOLV ITX

$55

IF YOU'RE BUILDING a budget PC, you've probably resigned yourself to the idea that you won't be able to afford a decent-looking chassis. The Enthoo Evolv ITX proves that this doesn't have to be the case. This sleek white system is absolutely gorgeous, yet will only set you back $55. The fact that we've used this chassis in far more expensive builds speaks volumes, really.

It's a breeze to build in, too, with Phanteks's eye for detail showing through in everything from build quality to material selection to fan placement. That single large 200mm fan behind the front panel keeps your components cool, and due to its size, it doesn't make any noticeable noise when doing so. Dust filters help keep your build clean, while Velcro straps keep your system airflow-friendly. And did we mention that it looks amazing as well?

PSU

CORSAIR CX550 $50

GO WITH KNOWN BRANDS. Especially when it comes to memory and power supplies. You may miss out on some real bargains by doing so, but what you will have on your side is consistency, and the reassurance that a big name brings to your build. And the warranty. Don't forget the warranty.

The CX550 is potentially overkill for this build, because we've ended up drawing just under 200W. However, having a beefier power supply makes upgrading easier—affording plenty of room for more hungry CPUs, GPUs, and more storage. Note that this unit arrived a little late for our photography, so we used an RM650 for that, but swapped it out for the CX550 for actual testing.

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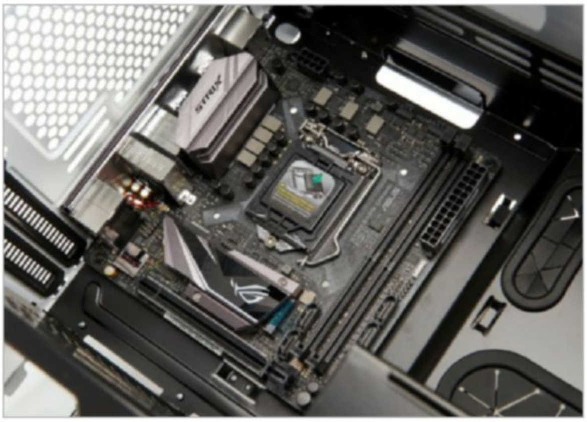
1

TAKE THE FIRST STEP

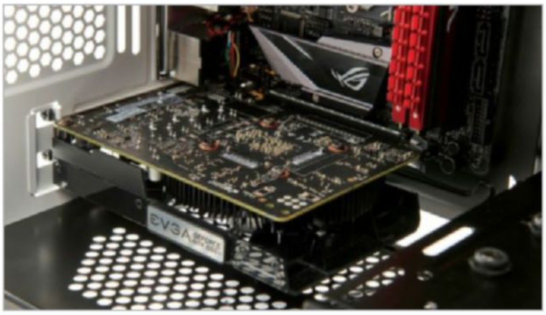
YOU KNOW THE ONE THING we almost always forget to do every time we build a system? Install the rear I/O plate. After you've got all your shiny new hardware unboxed, prepped somewhere sensible to build your new rig (no woolen socks, or fluffy carpets), and stripped your case of any unnecessary hard drive cages and accessory boxes, install your mobo rear I/O shield. It helps reduce potential static discharge from your cables and peripherals, and also reduces the amount of dust entering your system. Once that's done, line up your motherboard with the pre-installed stand-offs, and secure it with the correct screws (often included in your case's accessory box/bag). It's worth noting that if you have an air tower cooler that requires a backplate, it's wise to install the backplate before securing the motherboard inside the chassis.



2

THE BEAUTY OF AN ITX BUILD

AFTER YOUR MOBO IS SAFE and secure, you can start installing the majority of your new hardware. We suggest the processor first. For Intel's LGA socket, lift the retention arm up and out, until the bracket can be lifted up. Gently place your new processor in, with the golden triangle on the corner of the CPU matching the triangle on the socket, then plop it into place. Don't force it, or try to push it down; simply place it, then give it a very slight wiggle with your finger, to make sure it's secure. Bring the bracket back down, secure it under the bottom torque screw, and bring the retention arm back down as well. The protective cover will pop off, and you're good to go. Next, you can install the memory—be sure to line up the notch at the bottom of each stick of DDR4 with the notch on the slot, then push it securely into place at both ends, until you hear a satisfying click. For the GPU, remove the screws securing the PCIe brackets in place, then slot your new graphics card into the single PCIe slot, before resecuring with the screws.



3

FAN-TASTIC

“YOU COULD SPEND much less on a case!” We hear you, but the Evolv ITX is a fantastic small form factor case to build in. And this is one reason why: It comes with an impressively large 200mm single fan intake at the front. Plugging this behemoth into your motherboard provides plenty of air to keep your system well fed, and it comes with a pretty substantial dust filter, too. And, if you really want, you could take it out and use a 240mm AIO here instead. Speaking of fans, once you’ve got this far, you’re going to want to install your CPU heatsink. By default, the Pentium G4600 comes with a stock Intel cooler, with pre-applied thermal paste. Simply align the fan pins with the holes in the mobo, click the fan into place, and lock the pins by turning them to the left.

4

STICKING IT TO THE STORAGE

NEXT UP IS STORAGE. By default, the Evolv ITX comes with a single 2.5-inch SSD mount in the rear. Simply slide the tray up off its rubber mounts, slot in your SSD, and secure it with the included screws (check your accessory bag). Then slide it back into place on those rubber grommets. You’ll spot the hard drive caddies for our 3.5-inch drive located below this, hidden by the PSU cover. Simply pull the two included trays out, unlock the securing latches on each side of a tray, line up your hard drive, and bring the two securing latches back into place. Then it’s simply a case of sliding the caddy back into the 3.5-inch drive cage. Make sure that the connection ports for the SSD are facing down, and your 3.5-inch drive ports are facing toward the rear panel.

5

FRONT PANEL PROBLEMS

AT LAST WE GET TO the first ITX niggle: front panel connectors. Things get pretty tight when you start installing cables like this. You can install the front panel audio connector before you insert the GPU without much worry—most cards have a cut-out to allow you to thread it under for just such a situation as this. However, front power, LEDs, and HDD indicators are trickier. The Strix Z270i comes with details on the motherboard about which connector needs installing where, but you may find you need to remove the RAM to install them a little more easily. One thing to note: The plus and minus for the LEDs need to be oriented the correct way around (as indicated in the motherboard manual, and on the board), otherwise they don’t work.

6

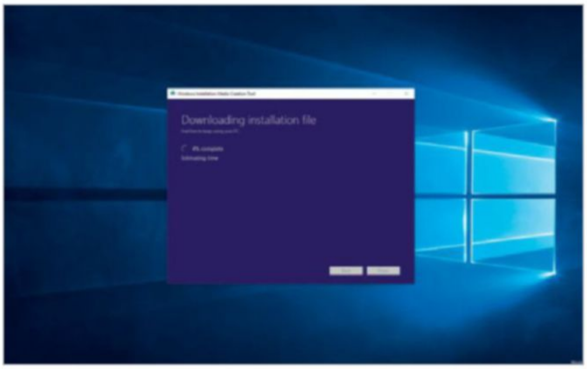
A TALE OF CABLES AND COVFEFE

NOW IT’S TIME to wrap up your build. Thread through your 24-pin power through the side rubber grommet, and the eight-pin power through the top grommet, and you’re good to go. The GTX 1050 Ti we’ve used here relies solely on power drawn from the PCIe slot itself, with no additional PCIe power needed. Finally, use two SATA powers for both the SSD and the HDD, and you’re sorted. After that, there are a few upgrade options you could go for. As seen here, the Evolv ITX supports 240mm AIOs in the roof, and on top of that, given the PSU, you could also upgrade to something along the lines of a GTX 1060 or 1070 with relative ease. Couple a 1070 with a Core i5 processor, for instance, and this little ITX build will be a quick, quiet, powerful 1440p gaming machine.

7

OS OF CHOICE

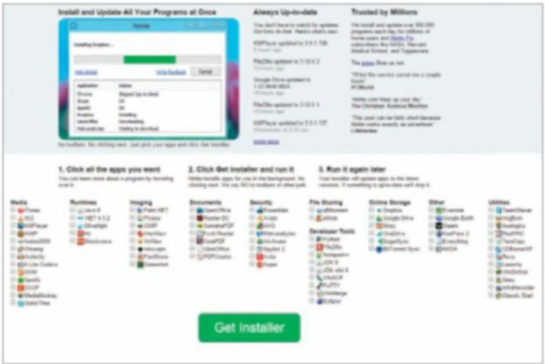
WITH ALL THE PHYSICAL work done, it's time to install Windows. To do this, grab yourself an 8GB USB stick and, on another system, head to http://bit.ly/Win10MediaTool, and download the Media Creation Tool from Microsoft. Run the program, select "Create New Installation Media" (make sure it's the x64 version), select your 8GB USB stick (bear in mind that it will be formatted), and let Windows complete the job. You then need to plug the USB stick into the back of your new system, power on, mash Delete, and change the boot order in BIOS so that "UEFI:[USB STICK NAME]" is at the top. Hit F10, save, and exit, then install Windows on to your brand spanking new SSD, entering your Windows 10 key when prompted.


Downloading installation file

8

MASS INSTALLATION

YOU'LL NOW WANT to run through some initial setup procedures. In this case, head to Asus's website, find your specific motherboard model's page, click "Support," then "Driver & Tools," select your OS (in our case, Windows 10 64-bit), and download Intel Chipset Driver, Management Engine Interface, and Realtek Audio Driver, and any other software you might need. Install the chipset driver before anything else. Then head to www.nvidia.com, and download GeForce Experience. Once installed, it should prompt you to download and install the latest drivers for the GTX 1050 Ti. One last thing: We suggest going to http://ninite.com, and grabbing all of your day-to-day programs' installers.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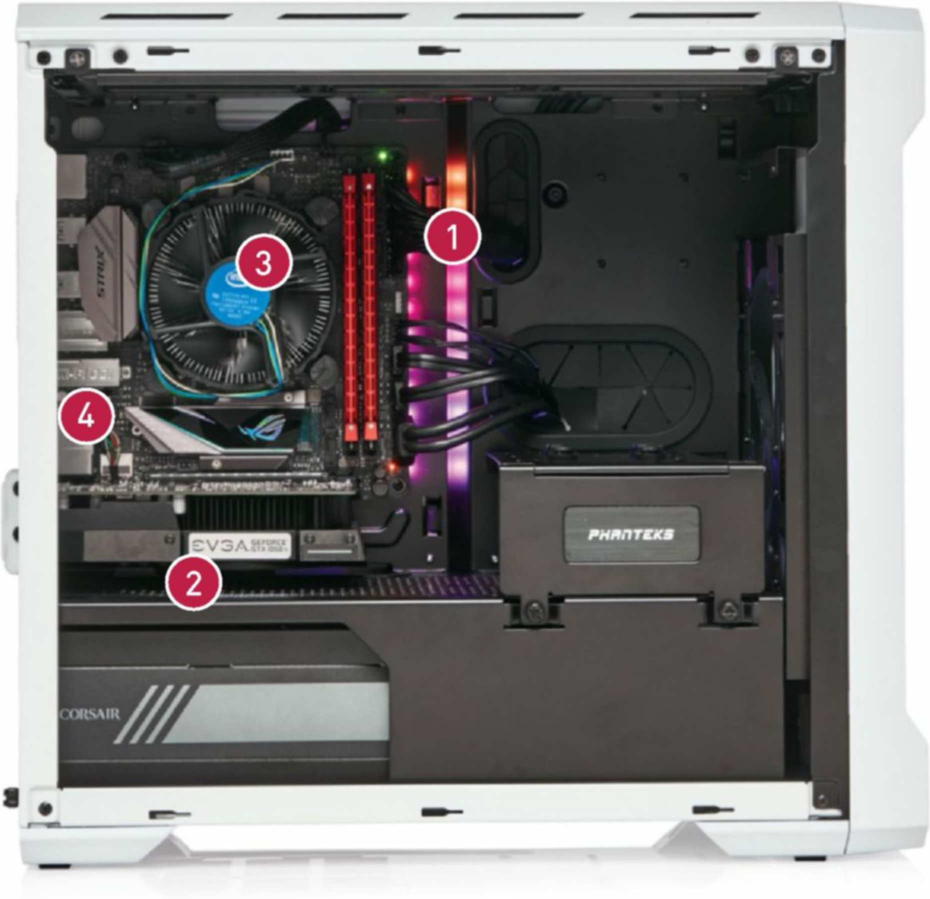
Always Up-to-date
Trusted by Millions
1. Click all the apps you want
2. Click Get Installer and run it
3. Run it again later
Get Installer

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi-Thread (Index)	507	375 (-26%)
Cinebench R15 Single-Thread (Index)	90	149 (66%)
TechARP x264 (Avg fps)	11.98	8.81 (-26%)
CrystalDisk QD32 Sequential Read (MB/s)	511	550 (8%)
CrystalDisk QD32 Sequential Write (MB/s)	105	495 (371%)
CrystalDisk Random 4K Read (MB/s)	21.94	20.90 (-5%)
CrystalDisk Random 4K Write (MB/s)	83.66	65.92 (-21%)
PCMark 8 Creative Accelerated (Index)	5,380	5,213 (-3%)
3DMark Fire Strike (Index)	7,835	6,270 (-20%)
Rise of The Tomb Raider (Index)	35	23 (-34%)
Far Cry Primal (Avg fps)	53	40 (-25%)
The Division (Avg fps)	57	36 (-37%)
Steam VR Performance Test (Index)	6.6	3.3 (-50%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point here is the $700 system we built way back in our October issue last year, featuring an AMD FX-8320E eight-core processor, AMD Radeon RX 480, 16GB of Corsair Vengeance Pro DDR3, and a Kingston SSDNow V3 120GB SSD. All games tested at 1080p at the highest graphical profile, with AA ramped up.



1 The RGB lighting included with the Asus Strix Z270i was a nice surprise—we didn't even know about it until powering it on.

2 The Phanteks Evolv ITX can support a full-sized GPU; the bracket to the right is designed with liquid cooling in mind.

3 The Pentium G4600 is still the best budget offering—at least until AMD drops its Ryzen 3 series processors on us.

4 In hindsight, saving $40 on the motherboard, and plumping for a GTX 1060 instead, may have been a better option.

IS $600 ENOUGH?

WHAT AN ODD TIME to be a gaming enthusiast! With both Project Scorpio and the PS4 Pro dropping, each promising 4K gaming at price points lower than $500, the argument for a budget gaming PC has come under quite a lot of scrutiny. After all, even this machine—specced at 600 greens—is only aimed at 1080p and no more. So, why invest in it as a platform if you're keen on gaming?

Well, of course, the answer isn't straightforward. First and foremost is the level of customization available to those on the PC platform. There's a lot of similarities that can be drawn between a Mac and a console. They're both very much locked down into specific settings and applications, limiting what you can do on them, and both are designed not to stress the hardware inside in any grand manner. That said, as time has passed and technology has advanced, there's now little difference between consoles and PCs from an architectural standpoint. Both use X86 as a coding platform, and both have hardware based off the same SKUs. In fact, the newly announced XBox One X has a slightly higher clocked RX 480 as the base of its graphics rendering chip.

If that's the case, how can they achieve that 4K 30fps "sweet spot" that Sony and Microsoft's marketeers clamor for? Again, it's back to that Mac comparison—everything is locked down, and in the console's case, graphical settings are gimped and optimized to their extremities to achieve that goal.

Turn to the PC, on the other hand, and there's no limit to what you can do with the platform. Not only when it comes to adjusting graphics to your particular preference, and smashing frame rates well above that console archetype in the process, but also regarding how you use it. Versatility is key. Whether that's playing flight simulators, RTS games, first-person shooters, or RPGs; using controllers, joysticks, HOTAS setups, or steering wheels; at 1080p, 1440p, 4K, 3440x1440, or with multiple screens; and with unlimited backward compatibility, and a roster of exclusives more far-reaching than any list ever provided by any of those sub-par living-room boxes—it's not hard to see why the PC as a platform is superior. And we don't even need to mention everything else you can do on a PC.

All that aside, it all comes back to that value proposition. How much is all that versatility worth? In our case, with this build, potentially less than you think. Of course, the GTX 1050 Ti isn't the powerhouse of gaming we'd like it to be; although you can successfully achieve 60fps in most 1080p titles with a bit of loving and some tweaking to AA and more, in our testing suite, we failed to hit the mark. And the Pentium G4600 is a fantastic budget offering, but if you're after rendering or doing any form of extracurricular gaming activities, it falls flat.

What our Kick Ass $600 machine does show, however, is how much extra you get by investing just a touch more cash. We're constantly harping on about what the sweet spot is for price to performance—in our case, October's $700 machine wipes the floor with today's $600 build. In fact, if you were to go a bit higher, and aim for a budget of $900-plus, you could make yourself a fairly sound 1440p gaming rig for just a little extra dough.

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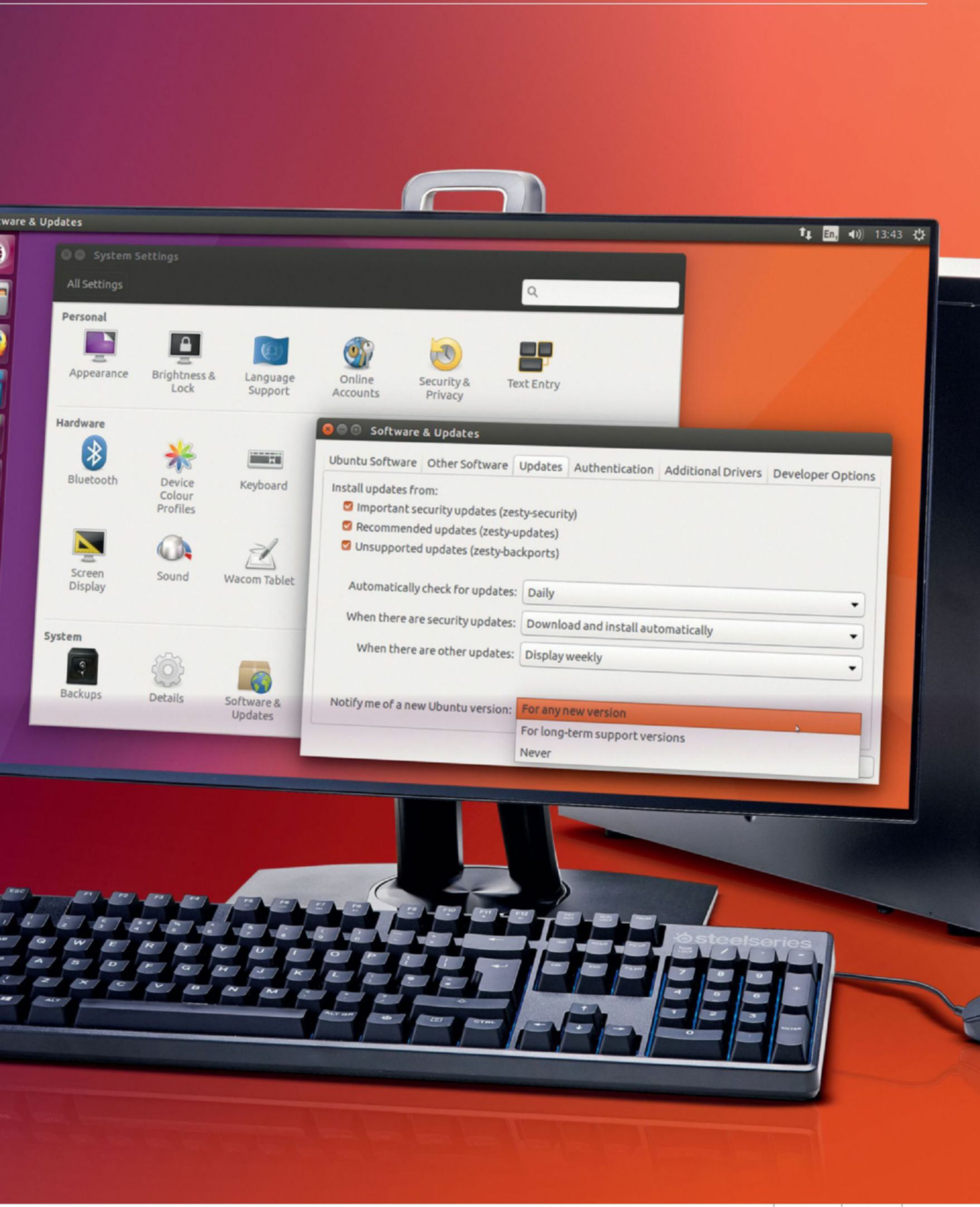
Everything You Wanted to Know About Linux... *But Were Too Afraid to Ask*

You don't need to be a complete beginner to get confused by a new operating system. *Nick Peers* looks for answers to your Linux-related questions

IT'S NEVER STRAIGHTFORWARD moving from one operating system to another. It doesn't matter how well versed you are in Windows, you can't simply transfer everything you know and apply it equally to your new OS—and that's particularly true when it comes to Linux, even when it's as user-friendly as Ubuntu.

Some things translate, of course—how many ways are there to point and click, after all? Nevertheless, there are still fundamental differences in the way Linux operates that you need to understand. Failure to do so could result in you breaking your system. In this feature, we take you on a tour of the key differences you'll encounter in Ubuntu, and give you a grounding in how they work and what to expect.

To begin, we examine the Linux filesystem, and how it handles users and permissions. There's a brief look at drivers, then we reveal how you find, install, update, and manage software. We also introduce you to the Terminal. Don't run away—it's neither scary nor a cure for insomnia. We finish by looking at what's new in the latest release (Ubuntu 17.04). No time to waste; a whole OS is out there, waiting for you to get to know it better.


ware & Updates
En
13:43
System Settings
All Settings
Personal
Appearance
Brightness & Lock
Language Support
Online Accounts
Security & Privacy
Text Entry
Hardware
Bluetooth
Device Colour Profiles
Keyboard
Screen Display
Sound
Wacom Tablet
System
Backups
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Software & Updates
Software & Updates
Ubuntu Software
Other Software
Updates
Authentication
Additional Drivers
Developer Options
For long-term support versions
Never
steelseries

Install updates from:

☑ Important security updates (zesty-security)

☑ Recommended updates (zesty-updates)

☑ Unsupported updates (zesty-backports)

Automatically check for updates: Daily

When there are security updates: Download and install automatically

When there are other updates: Display weekly

Notify me of a new Ubuntu version: For any new version

Navigate the Linux Filesystem

Don't be shocked by the way Linux handles files—it's actually quite logical

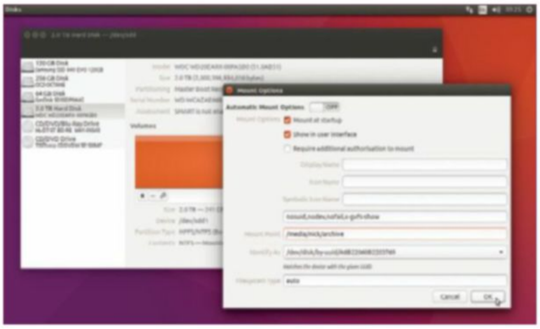
THE LINUX FILESYSTEM (ext2, ext3, and ext4) is radically different to Windows. The key change is how it references drives and partitions—not as separate, distinct drive letters, but as files within the main filesystem itself. It is logical, though, and it won't take you long to adapt.

Open the Dash, and type "disks" to open the Disks utility, to help you visualize how things work. Select a drive in the left-hand menu, and look in the Disks menu bar. You'll see your drive is referenced something like /dev/sda. This refers to the "dev" (devices) folder, inside which each physical disk is assigned a unique file, which begins "sd" (for "storage device"), followed by a unique letter from "a" through "z."

This follows a logical pattern: /dev/sda is assigned to the drive Ubuntu is installed on, with drives then allocated "sdb," "sdc," and so on, following the order of internal drives first, then external media (both flash and hard drives) second. The logic extends to partitioning, so instead of assigning partitions (or "volumes") separate drive letters, Linux identifies each with individual files named "sda1," "sda2," and so on. Partitions are represented in the bar chart for each drive in Disks. Numbering isn't always logical—if your drive is formatted using the MBR (Master Boot Record) partitioning scheme, for example, you may notice any additional partition you've set up is allocated "sda5" and not "sda2." Don't worry, though—it's all working as it should.

Accessing Drives

Drives aren't just incorporated into the main filing system as individual files, they're also "mounted" to specific folders within the filesystem, which is where their contents can be found. Your main system partition (typically /dev/sda1) is mounted to the root directory (/) of the filesystem. Other internal and external volumes aren't mounted by default (although external drives mount automatically if you plug them in after logging on to Ubuntu), while the swap file isn't mounted, period.


Use the Disks utility to configure volumes to mount automatically when you start Ubuntu.

LINUX ISN'T WINDOWS

Ubuntu's Unity desktop does a good job of masking the fact that Linux and Windows are very different operating systems. There's the small matter of the filesystem, of course, and Linux is much tighter with security than Windows. Windows has closed the gaps in some areas—file and folder permissions, for example—but in others, Linux remains way out in front. For example, you can't perform an administrative task in Linux—such as installing updates or a program—without supplying your user password. It's this attention to detail that makes Linux far less vulnerable to malware and hackers.

Also, despite appearances, Linux remains very much an operating system that performs best from the underlying shell environment. Unity is a good front end, but as you'll see later on in this feature, don't resist embracing the command line through the Terminal.

Other things to consider: Ubuntu is a much more open, community-supported environment than Windows. It's packed with free (and open source) software, helping drive down computing costs, but most support is found online, through forums and asking questions of your peers. The way Linux handles software—via centralized repositories and package managers—is another thing you need to get used to.

One final thought: Hardware compatibility is no longer the issue it was either. While some devices don't work, you'll find most do, and many don't require any additional configuration—they just work.

The simplest way to access your files and folders is via a file manager—Ubuntu's default Files program is based on a tool called Nautilus, and is similar to File Explorer in Windows. Open it by clicking the filing cabinet icon in the Dash, and you'll see a list of available volumes appear in the left-hand navigation pane. Click one to mount it—an eject button appears next to it, indicating the drive has been successfully mounted.

These shortcuts are convenient, but where are these drives physically mounted within the Linux filesystem? Click "Computer" in the Navigation pane to navigate to the root directory, then browse to "/media/<yourname>" to find folders pointing to each drive that you have physically mounted.

It's also possible to mount key folders on separate volumes, too—for example, many Linux installations set up a dedicated partition for the /home folder during the installation process, where all your user settings and data, including such folders as Documents, Downloads, and Pictures, are stored. (Ubuntu is one of the few that doesn't do this.)

Mount on Startup

If you'd like Ubuntu to automatically mount specific volumes at startup, saving you the bother of having to click them manually, open the Disks utility, select your drive on the left, then highlight the volume by clicking it on the bar chart. Now click the "Settings" button beneath it, and choose "Edit Mount Options." Flick the "Automatic Mount Options" switch to "On," and make sure the first two options are selected, then change the "Mount Point" field to "media/user/label," substituting "user" with your username, and "label" with the volume label. Click "OK," then reboot to verify the drive mounts automatically.

Another key aspect of the Linux filesystem is file permissions, which we discuss on the next page.

Introducing File Permissions

Users, superusers, and file permissions—controlling access to data

ANY FILESYSTEM WORTH ITS SALT applies restrictions to files in the form of permissions, limiting access based on users and groups. Windows does this to some degree with its NTFS filesystem, but it's no substitute for Linux.

The Basics

Everything in Linux is represented as a file, including folders and hardware devices. The ext filesystem applies permissions to these files to determine how they can be accessed, and by whom. These boil down to three basic levels of access: read, write, and execute, expressed as r, w, and x respectively. You can view a file's permissions in the Terminal with the "ls -l" command, where you'll see entries such as "rwx" (full access) or "r--" (read-only).

These "rwx" permissions apply to folders as well as files, and things are complicated by the fact that certain permissions—such as deleting a file—reside with its parent folder, not the file itself. Files can be viewed (r), edited (w), and executed if they're a program (x), but unless their parent folder has "w" permissions, you can't create (or delete) files within the folder. Similarly, you can't view files unless the folder has "x" permissions.

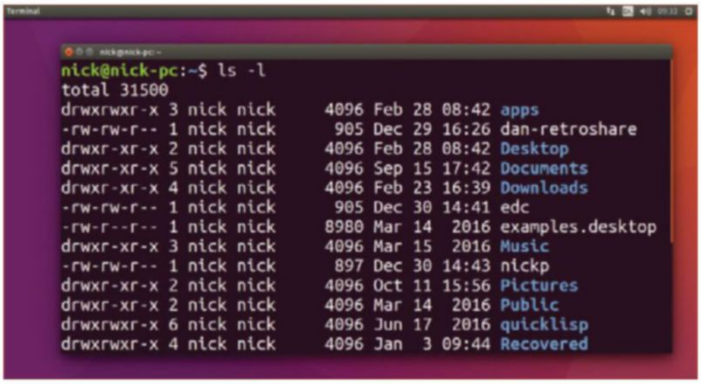
Owners, Users, and Everyone Else

Security is paramount in Linux, so permissions aren't applied directly to each file and folder; they're applied to three categories of user: owner (the user who created the file), specific user group, and "others" (everyone else).

The second category refers to a single user group for whom specific permissions have been defined. Although it appears to apply to a specific user (often the file or folder's owner), it actually applies to a user group.

When you create a new user, a group of the same name is also created, your user is added to that group, and it's this group that Linux references here. You can add users to multiple groups, so advanced users can set up groups into which multiple users are added, giving them all the same level of access to a file or folder based on the group.

Permissions are set when a file is created, with the file owner also set as the default user or group for the file. If you create a file when running in elevated mode (such as through "sudo" in the Terminal), the owner is "root," not you. The owner typically has full access rights to the file or folder created, while "everyone else" has more limited rights to files, and is usually blocked from folders.



```
nick@nick-pc:~$ ls -l
total 31500
drwxrwxr-x 3 nick nick     4096 Feb 28 08:42 apps
-rw-rw-r-- 1 nick nick      905 Dec 29 16:26 dan-retroshare
drwxr-xr-x 2 nick nick     4096 Feb 28 08:42 Desktop
drwxr-xr-x 5 nick nick     4096 Sep 15 17:42 Documents
drwxr-xr-x 4 nick nick     4096 Feb 23 16:39 Downloads
-rw-rw-r-- 1 nick nick      905 Dec 30 14:41 edc
-rw-r--r-- 1 nick nick     8980 Mar 14  2016 examples.desktop
drwxr-xr-x 3 nick nick     4096 Mar 15  2016 Music
-rw-rw-r-- 1 nick nick      897 Dec 30 14:43 nickp
drwxr-xr-x 2 nick nick     4096 Oct 11 15:56 Pictures
drwxr-xr-x 2 nick nick     4096 Mar 14  2016 Public
drwxrwxr-x 6 nick nick     4096 Jun 17  2016 quicklisp
drwxrwxr-x 4 nick nick     4096 Jan  3 09:44 Recovered
```

Use "ls -l" in the Terminal to view file and folder permissions within the current directory.

By default, all users have full ownership, access, and control over their home folder and its contents, while other users are blocked. Outside the home folder, access is more restrictive—certain folders are accessible, but most are read-only or off limits completely, requiring you to access them via the "root" superuser account.

View and Change Permissions

It's possible to change a file or folder's permissions, if you're the owner, via the Nautilus file manager. Right-click the folder or file in question, and choose "Properties → Permissions tab." From here, you can change permissions for owners, the featured group, and "others," plus change which user group has special access to the item in question. Click the "Group" drop-down menu, and the list includes a load of unfamiliar names—these are specially created system users, designed to do specific things without compromising on security. There's no reason to use these groups in the context of file and folder permissions, so leave them well alone.

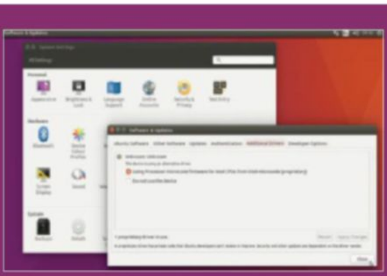
DRIVERS

One of Ubuntu's strengths is that "it just works" applies to hardware. It's gone to great lengths to ensure that when you install Ubuntu, you're not left trying to source (never mind install) key drivers.

Ubuntu even works with your graphics card or chipset with no problems, although if you plan to use your PC for gaming, you may have to investigate third-party alternatives—Nvidia and AMD users should open System Settings, and go to "Software & Updates → Additional Drivers." After a short delay, choose the latest version marked "proprietary, tested," click "Apply," then reboot.

To add a printer, go to "System Settings → Printers," and click "Add" to see if it's automatically detected; follow the wizard to see if drivers are included. If not, visit the manufacturer's website to see if there's a Linux driver. If it's a .deb package, installation is simple; if not, you may have to look for a .sh installer—ensure the file is executable (check "Allow executing file as a program" on the "Permissions" tab of the file's properties in Nautilus), open Terminal, navigate to the file's directory, and launch it thus:

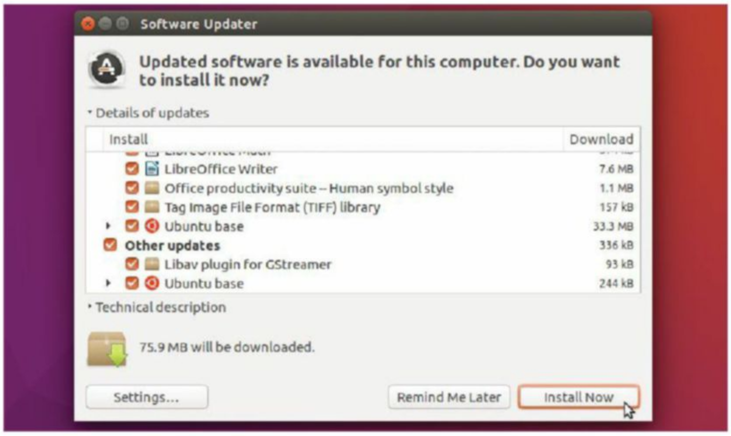
```
$ ./filename.sh
```



Check to see what graphics drivers Ubuntu is using via Software & Updates.

Installing Software

There are many ways to install software—in and outside the Terminal



Software Updater

Updated software is available for this computer. Do you want to install it now?

▾ Details of updates

Install	Download
☑ LibreOffice Writer	7.6 MB
☑ Office productivity suite – Human symbol style	1.1 MB
☑ Tag Image File Format (TIFF) library	157 kB
▸ ☑ Ubuntu base	33.3 MB
☑ **Other updates**	336 kB
☑ Libav plugin for GStreamer	93 kB
▸ ☑ Ubuntu base	244 kB

▸ Technical description

75.9 MB will be downloaded.

Software installed from repositories is automatically updated when necessary.

MANY LINUX PACKAGES are stored in what are called online "repositories." These are channels that usually bundle together software of similar types, built for specific versions of Ubuntu (so Ubuntu 17.04's repos aren't the same as those for Ubuntu 16.10, or indeed 16.04). There are four main channels for each separate version: Main, Restricted, Universe, and Multiverse.

The Main repo contains free software that can be redistributed freely, and is fully supported by Ubuntu with regular updates. Universe contains a vast array of free and open source software, where the community provides updates. Restricted houses a small set of proprietary (closed source) tools and drivers required to support Ubuntu on everyday hardware, while Multiverse contains software that is not free nor supported.

These repos can then be accessed by package managers, such as Software Center, to provide you with a convenient central location for locating, installing, and—where supported—automatically updating packages.

Beyond Repositories

The vast majority of programs that you need can be found with these four main repos. If you find the Software Center a bit limited, try a more robust (and a little more advanced) package manager by searching for "Synaptic" to install the Synaptic Package Manager. This provides a more thorough search of repos to help you find the packages you're looking for, and provides a more comprehensive list of programs out of the box.

Not all programs are available through the default repos—some offer their own, which you can add to your package manager one of two ways: either via "Settings → Software & Updates → Other Software," or through the Terminal (see right). Once installed, you're alerted to any updates when they're made available by the software maintainers.

Other programs can be downloaded individually as packages, which work in a similar way to program installers in Windows. These contain everything that's needed for the program to run successfully—not just programs, but references to dependencies, too, which you're prompted to install if they're not already on your system. These files often come with a .deb extension—save this to your Downloads folder, then double-click the file to proceed—your package manager should take over at this point. Note that while it records the installation, your package manager can't detect any updates—that's down to the program or its maintainer.

Install From the Terminal

Familiarize yourself with the "apt" range of tools, and you'll find most of the time the Terminal is the quickest and best way to install stand-alone software packages. Start with the following command:

```
$ sudo apt-get update
```

This retrieves the latest package lists (including updated versions) from all installed repositories. The following two commands install and remove software:

```
$ sudo apt-get install <package>
$ sudo apt-get remove <package>
```

The following updates all installed software:

```
$ sudo apt-get update && sudo apt-get upgrade
```

You can also add repositories via the Terminal. Many third-party repos are hosted at https://launchpad.net and can be added using the following command:

```
$ sudo add-apt-repository ppa:<repository name>
```

THE TERMINAL

While Ubuntu's Unity desktop provides a familiar point-and-click environment for day-to-day tasks, it's no match for the power and versatility of the Linux shell, the underlying command-line environment. And thanks to the Terminal, you can interact with the shell without leaving the desktop.

The shell utilizes a language called BASH to run specific commands using a series of tools. Each command follows the same basic structure:

```
$ utility command -option
```

The "utility" bit is the tool you wish to run—for example, "cd" to change directory, or "apt-get" to run the package management tool. Some utilities can be run on their own—type "ls" to get a basic list of all files and folders in a directory, for example.

If you add a "command" to the utility, you can specify what you want that utility to do:

```
$ apt-get install program
```

This instructs the package management tool to install the named program. The "-option" section is where you specify preferences using "flags." Each flag is preceded by one (-) or two (--) dashes. For example, to get more detailed information about the contents of the current folder, type:

```
$ ls -l
```

The "-l" flag ensures you get extra snippets, such as file permissions and owner, plus the date it was last modified, and its size in bytes.

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Top Tips for Linux Switchers

Start making good use of the Terminal with this collection of commands

Get Help

There are three ways to get help in the Terminal. Know the name of the tool? Use the "--help" flag:

```
$ ls --help
```

The "whatis" tool is also useful, providing you with a brief description of a fully formed command:

```
$ whatis apt-get install vlc
```

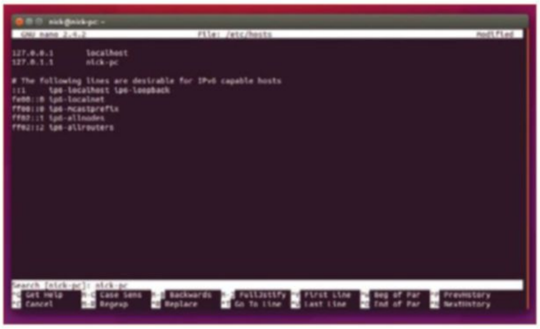
This describes the "apt-get" tool, the install argument, and the package "vlc." Note: "whatis" ignores any flags.

The Terminal also provides access to an online manual via the "man" utility. Start with "man intro" for a detailed intro to the Terminal, and "man man" for advice on navigating the manual. Pair it with a tool—for example, "man apt-get"—for a detailed description of that tool.

Navigating the Filesystem

Open the Terminal, and you start in your home folder. Use "ls -l" to confirm this. If you'd like to view all hidden files and folders (file names with a period at the beginning, such as ".hidden.sh"), use "ls -a." View the contents of subfolders in the current folder with "ls --recursive."

The "cd" command allows you to quickly move between directories. To move inside a subfolder within the current folder, use "cd Dirname" (folders and files are case-sensitive). To go back up a level, use "cd .." or "cd ../.." to jump up two levels. To navigate to the root directory, use "cd /" or type "cd ~" to go to your home directory.

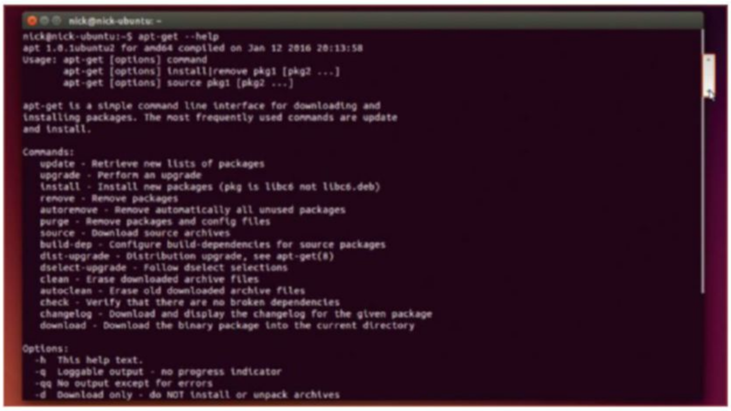


```
127.0.0.1       localhost
127.0.1.1       nick-pc

# The following lines are desirable for IPv6 capable hosts
::1     ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff00::0 ip6-mcastprefix
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters

Search [nick-pc]: nick-pc
```

Use "nano" to edit config files without leaving the Terminal.



```
nick@nick-ubuntu:~$ apt-get --help
apt 1.0.1ubuntu2 for amd64 compiled on Jan 12 2016 20:13:58
Usage: apt-get [options] command
       apt-get [options] install|remove pkg1 [pkg2 ...]
       apt-get [options] source pkg1 [pkg2 ...]

apt-get is a simple command line interface for downloading and
installing packages. The most frequently used commands are update
and install.

Commands:
   update - Retrieve new lists of packages
   upgrade - Perform an upgrade
   install - Install new packages (pkg is libc6 not libc6.deb)
   remove - Remove packages
   autoremove - Remove automatically all unused packages
   purge - Remove packages and config files
   source - Download source archives
   build-dep - Configure build-dependencies for source packages
   dist-upgrade - Distribution upgrade, see apt-get(8)
   dselect-upgrade - Follow dselect selections
   clean - Erase downloaded archive files
   autoclean - Erase old downloaded archive files
   check - Verify that there are no broken dependencies
   changelog - Download and display the changelog for the given package
   download - Download the binary package into the current directory

Options:
  -h  This help text.
  -q  Loggable output - no progress indicator
  -qq No output except for errors
  -d  Download only - do NOT install or unpack archives
```

The Terminal comes with lots of help and documentation for you to plunder as required.

Type "cd /path/to/folder" to jump to another folder using its exact path ("cd ~/Document" if it's in your home folder). Type "cd -" to go back to the previous directory.

If your folder path contains spaces—for example, a folder named "Star Trek," you need to encompass the entire path inside single quotation marks, like so:

```
$ cd '~\Videos\Star Trek'
```

Copy, Move, and Delete

Need to manipulate files within the Terminal? Start by familiarizing yourself with the "cp" (copy) and "mv" (move) tools, which share the same syntax:

```
$ cp -i source destination
```

Both "source" and "destination" can be complete folder paths, or just use the file name if you've already navigated to the folder containing the original file, while the "-i" flag ensures you'll receive a warning if you try to overwrite an existing file of the same name. For example:

```
$ cp -i invoice.odt ~/Documents/Backup
```

If you want to rename the copied file, simply append it to the end of the destination: "~/Documents/Backup/invoice-backup.odt," for example. Similarly, "cp invoice.odt invoice-backup.odt" creates a renamed duplicate of the original file in the same folder. Substitute "mv" if you wish to move—or rename—a file. If you want to copy

GET SYSTEM INFORMATION

The Terminal provides a host of tools for divulging key info about your hardware. Start with the following command for a table-like summary of your hardware:

```
$ sudo lshw -short
```

You can also output a full-blown detailed report for viewing in a browser:

```
$ sudo lshw -html > sysinfo.html
```

Other related tools include "lscpu" (CPU info), "lsblk" (storage devices), "lspci" (internal hardware), and "lsusb" (USB devices). They all work differently—for example, "sudo lspci -v" provides a summary, while "lsusb" works best if you identify the device you wish to check out via "sudo lsusb," then use the following based on its bus and device number:

```
$ sudo lsusb -D /dev/bus/usb/00x/00y
```

Finally, "dmidecode" provides useful information via the "-t" flag and keywords such as "bios," "baseboard" (mobo), "processor," "memory," and "chassis"—for example, "sudo dmidecode -t memory." But be warned: The DMI tables it polls aren't always accurate, so don't be shocked if things don't stack up.

Use "lshw" to create an HTML file displaying a handy summary of your PC's hardware.

a folder, use the "-r" flag to indicate recursion, which means the folder and its contents are copied or moved.

Delete individual files using "rm," and empty folders can be removed with the "rmdir" command (add the "-r" flag to delete a folder and any existing contents):

```
$ rmdir -r ~/Documents/Backup
```

Create folders using "mkdir foldername" (again, full paths are supported), and use "touch filename" to create a new, empty file—for example, "touch config.sys." When creating folders with spaces in the name, surround them with single quotation marks or place a backslash (\) before the space—for example, "mkdir Star\ Trek."

Change Permissions

Nautilus provides some tools for tweaking permissions, but it's quicker to use "chmod" with the following syntax:

```
$ chmod 777 file
```

The "file" is obviously the name of the file, and can also refer to a folder. If you want to set all the folder's contents—including subdirectories—to the same permissions as the folder itself, add the "-R" flag, like so:

```
$ chmod -R 777 folder
```

The key element is the "777," which refers to the permissions: "7" stands for "rwx" (full access), and the first number refers to the file owner, the second to the file's group, and the third to "everyone else."

Other numbers worth considering are "6" (rw-, or read/write but not execute), "5" (r-x, or read and execute), and "4" (r--, or read-only). So, assign 644 to a folder or file and you're giving the owner read and write access, but restricting all others to read-only access. Set 775 and you're giving the owner and named group full access, while everyone else can read and execute the file.

Before diving into permissions, read https://help.ubuntu.com/community/FilePermissions for a full brief.

Change User and Owner

If you want to change the owner or group of a selected file or folder, use the "chown" command.

```
$ chown user file
```

You can use "chgrp" to change the group of a file, using the same syntax ("chgrp group file"), or use "chown" to change both user and group with one command, like so:

```
$ chown owner:group file
```

Run Multiple Commands Together

There are three ways to join two or more commands together on a single line (allowing you to go off while your PC gets on with it). If you only want the second command to run if the first completes successfully, use "&&":

```
$ sudo apt-get update && sudo apt-get upgrade
```

If you wanted the second command to run only if the first command failed, then substitute "||" for "&&." Finally, use a semi-colon (;) to run the second command regardless of what happens with the first:

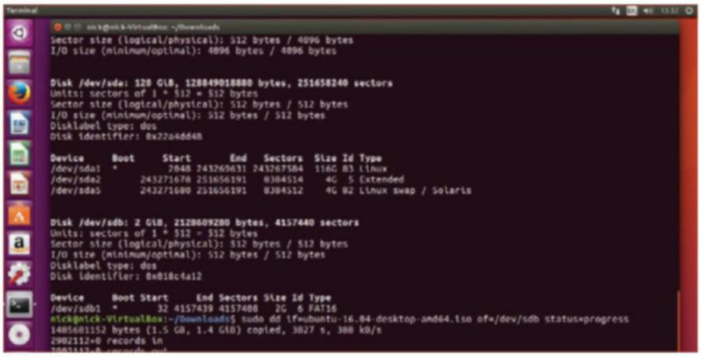
```
$ sudo apt-get update ; sudo apt-get remove vlc
```

Editing with Nano

One popular use for the Terminal is to edit configuration files. The best tool for the job is "nano," which works just like a regular text editor. Invoke it thus:

```
$ sudo nano /path/filename
```

You'll see the Terminal change to the Nano interface—the file name and path are listed at the top, and a list of basic commands are shown at the bottom; the ^ symbol refers to the Ctrl key. Your file's contents take up the main area of the Nano interface—there's no text wrapping, so look for "$" symbols on the right indicating the line doesn't fit (resize the window or press End to jump to the end of the line).



```
Sector size (logical/physical): 512 bytes / 4096 bytes
I/O size (minimum/optimal): 4096 bytes / 4096 bytes


Disk /dev/sda: 120 GiB, 128849018880 bytes, 251658240 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x22a4dd48

Device     Boot     Start       End   Sectors  Size Id Type
/dev/sda1  *         2048 243269631 243267584  116G 83 Linux
/dev/sda2       243271678 251656191   8384514    4G  5 Extended
/dev/sda5       243271680 251656191   8384512    4G 82 Linux swap / Solaris


Disk /dev/sdb: 2 GiB, 2128609280 bytes, 4157440 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x018c4a12

Device     Boot Start     End Sectors Size Id Type
/dev/sdb1  *       32 4157439 4157408   2G  6 FAT16
nick@nick-VirtualBox:~/Downloads$ sudo dd if=ubuntu-16.04-desktop-amd64.iso of=/dev/sdb status=progress
1405681152 bytes (1.5 GB, 1.4 GiB) copied, 3027 s, 388 kB/s
2982112+0 records in
```

Create bootable flash drives from ISO files using the "dd" tool.

Use Home and End to jump to the start and end of a line, or PgUp and PgDn to move pages at a time. Press Alt-/ to go to the bottom of the document, and Alt-\ to jump back to the top. Use Ctrl-W to search your file, pressing Alt-W to look for additional matches.

Write to USB

Need to create a bootable USB drive from an ISO file you've downloaded? The "dd" tool leaps to the rescue, but use with care—the following command wipes the target drive as part of the copy operation, so be sure you've identified the correct drive before you begin using "sudo fdisk -l":

```
$ sudo dd if=filename.iso of=/dev/usb status=progress
```

Substitute "/dev/usb" with the correct drive identifier (such as "/dev/sdc").

SU-SU SUDO

When you open the Terminal, you log on to the underlying shell via your user account, with limited access to the Terminal. Certain commands require elevated access as the root user (look for "permission denied"), and you achieve this by preceding the command with "sudo," like so:

```
$ sudo apt-get install vlc
```

You're prompted for your own user account password, and the command now runs—you should now be able to use "sudo" again during the current Terminal session without being prompted for your password. By the way, if you forget to include "sudo" in a command, just type "sudo !!" and hit Enter to repeat the command with sudo applied.

If you want to launch a desktop app with root privileges (such as the Nautilus file manager), use the "gksu" tool, which you first need to install as follows:

```
$ sudo apt-get update && sudo apt-get install gksu
$ gksu nautilus
```

Nautilus opens as normal, but with elevated access. Make sure you leave the Terminal open while the app is running, otherwise it closes when the Terminal does. When you're done, close the app window, then press Ctrl-C in the Terminal, which interrupts the currently running program, and returns you to the command line.

Some distros allow you to log on to the command line as the root user with the "su" tool, but Ubuntu explicitly blocks this, and for good reason. We suggest sticking with the "sudo" tool instead.

Swap Out Your Desktop

Ubuntu is changing its default desktop, so why not try alternatives?

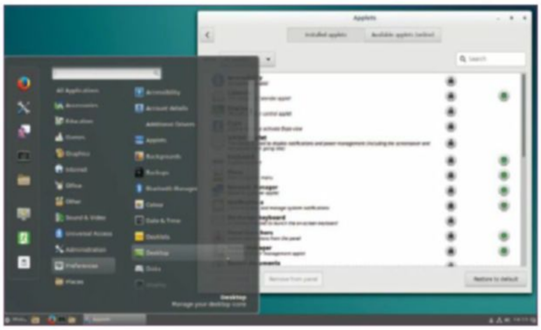
ONE OF LINUX'S STRENGTHS is its versatility, and unlike other OSes, that extends to your desktop. Each flavor of Linux ships with its own desktop environment, and while they share superficial similarities—specifically the point-and-click WIMP interface—there can be quite radical differences, in functionality, as well as look and feel.

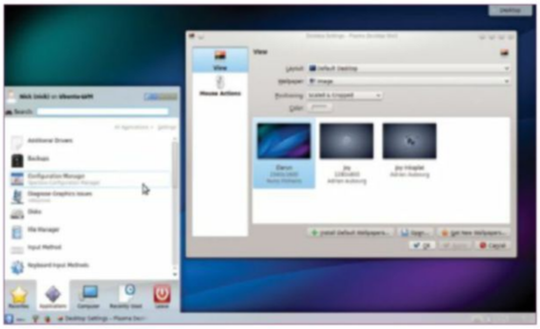
Ubuntu 17.04 ships with two desktops: Ubuntu and Unity8. Ubuntu is the Unity7 desktop, which developer Canonical has announced will be dropped from Ubuntu 17.10. Unity8 is incomplete, full of bugs, and not suitable for day-to-day use, but is worth checking out to see what may have happened if Canonical continued development.

The good news is that you're not restricted to either—Linux allows you to install multiple desktops, and switch between them, so you can compare different desktops side-by-side, or set up different ones for different uses.

Choosing a Desktop

Desktops are distributed as software packages. Once they have been installed, you switch between them from the login screen, by clicking the desktop icon that appears in the logon box next to your username. There are lots available, but many share similar traits. This is because these are all based on one desktop called GNOME (www.gnome.org). GNOME will become the default Ubuntu desktop as of the next Ubuntu release—the box reveals how to install it, along with another GNOME variant, Cinnamon (http://developer.linuxmint.com). One notable exception to the GNOME rule is KDE Plasma 5 (www.kde.org), which offers a radically different desktop that will appeal more to advanced users.


The Cinnamon desktop is a good choice if you're looking for a more Windows-like desktop environment.


KDE Plasma 5 offers a radically different desktop experience, but comes with a steeper learning curve.

Which desktop is best for you? Looks play a part, but there are questions surrounding configurability, user-friendliness, and performance. There's also a question of performance and power consumption. Unity and KDE 5 are better suited to powerful desktops, while lightweight alternatives such as Xfce (www.xfce.org) and LXDE (www.lxde.org) are perfect for older PCs and laptops. Run a couple, and see how they perform—you should notice those with a smaller footprint are the most responsive. They also place fewer demands on power consumption, which should benefit those running on batteries.

Thanks to the fact you can easily switch desktops, you could run two or more for different purposes, such as a lightweight desktop for working on the go, while switching to GNOME or Unity when plugged into the mains.

Working with Desktops

Once you've installed a new desktop (or two), log out of your account. When you find yourself back at the login screen, you should see an icon next to your username. Click this, and you'll see a list of available desktops appear—in some cases, you'll see multiple options based on a single desktop (it's basically the same desktop, but set up differently). Select one, then enter your password, and log in as normal to start using it.

When you log into a new desktop for the first time, it's a blank canvas—none of your existing preferences come across from your old desktop environment (but don't worry, they're all still there, ready and waiting for you the next time you log back into your original desktop).

One of the benefits of having to make changes to your new desktop early on is that it forces you to explore it as you set it up, providing insight into how it works, and what tweaks you can perform. And if you don't like this desktop? No problem, just switch back or try another.

TWO DESKTOPS TO TRY

If you want to get ahead of the curve and install the GNOME desktop that future versions of Ubuntu will be using, open a Terminal window, and type the following commands:

```
$ sudo apt-get update
$ sudo apt-get install ubuntu-gnome-desktop
```

A configuration wizard appears—choose the "lightdm" option when prompted. Once installed, log out, and click the Ubuntu logo next to your username—you'll see three new options, all variants of GNOME 3 (vanilla, Classic, and Wayland). Select one and log in to switch desktop.

Don't like GNOME? Itching for something a bit closer to the Windows desktop you left behind? Then give Cinnamon a try instead—it's the official desktop for Linux Mint:

```
$ sudo apt install cinnamon-desktop-environment -y
```

Cinnamon is highly configurable. Its main customizable elements—known as "spices"—are its themes, applets, desklets (widgets you can place on the desktop), and extensions. These enable you to radically alter its capabilities, as well as its look and feel.

What's New in Ubuntu 17.04?

Discover what's new, improved, and removed in the latest release

UBUNTU 17.04 was released only a couple of months ago, and contains several new features and beneath-the-hood changes. The release was overshadowed by the news that Canonical—Ubuntu's developer—has decided to retire its current desktop, Unity. All development has been ceased, and while Unity 7 remains the default for this release, it will be replaced by the GNOME desktop in Ubuntu 17.10.

But what else is new in Ubuntu? One change—hidden from view—is that Ubuntu has switched from storing virtual memory in a separate, dedicated partition to using a swap file in a similar fashion to Windows. If you're upgrading to Ubuntu 17.04 from an earlier release, the existing partition structure remains in place, but if you install from scratch, it defaults to a single partition with swap file. If you don't like this, you can manually configure the swap partition during setup by using the "Something else" option. A word of advice: If you're configuring a dual-boot system, don't follow this step unless you're supremely confident of what you're doing.

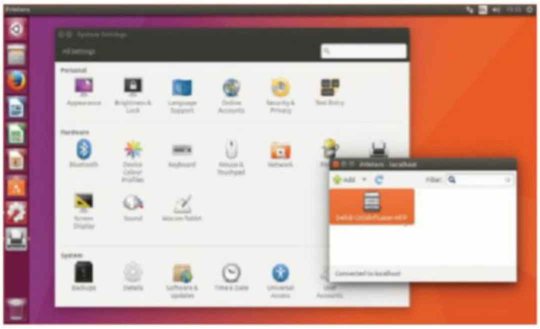
Driverless Printing

An increasing number of printers work without the need for drivers—basically, if you have a printer marked as IPP Everywhere or Apple AirPrint compatible, you no longer need to install drivers to make it work in Ubuntu, a tricky process at the best of times. A handful of PDF, PostScript, and PCL printers also work, and all you need to do is plug them in via USB or Ethernet, then go to "Settings → Printers," where you should find they're already detected, and ready to use or configure.

Under the Hood

Ubuntu 17.04 bases itself on the Linux kernel 4.10, so you can run it on the latest Intel Kaby Lake and AMD Ryzen systems. It also includes a big bump in the Mesa 3D graphics library to version 17.0.2, while X.Org Server 1.19.2 is also included. Both have benefits for gaming.

The default apps have also been updated—most notably LibreOffice 5.3, which includes the new ribbon-based interface, and the Calendar, which now offers a weekly view. A full list of changes can be found at https://wiki.ubuntu.com/ZestyZapus/ReleaseNotes, where you will find such incomprehensible delights as discovering Ubuntu 17.04 uses a new default tool—"systemd-resolved," as you asked—for resolving DNS addresses.



Printer setup just got a lot easier in Ubuntu 17.04 for IPP Everywhere and Apple AirPrint printers.

Toward Ubuntu 17.10

If Ubuntu 17.04 is a relatively minor update, there are larger ripples on the horizon. We've mentioned how Ubuntu 17.10 will be the first version to sport the GNOME desktop, which will be tweaked for Ubuntu users. Canonical is busy integrating the current Ambiance and Radiance themes to work with GNOME, for example. However, certain features exclusive to Unity won't be forthcoming in this next release—if you like the heads-up display or global menus, you'll have to source alternatives. Unity will remain an option if you upgrade from Ubuntu 17.04, or you'll be able to install it as an alternative desktop on new Ubuntu 17.10 installs.

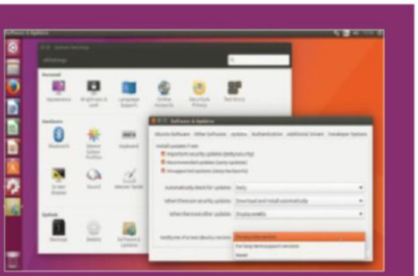
Ubuntu 17.10 will ship with a new default windowing system, replacing the X Window System (in the form of the X.Org Server) with a simplified replacement called Wayland, which comes with the promise of performance improvements, particularly when rendering 3D. X.Org Server should remain an option for now at the login screen, for backward compatibility purposes.

HOW UBUNTU UPGRADES WORK

Ubuntu releases major new versions of itself every six months. These are named for the year and month (4 for April, 10 for October) they're released. So, the latest release, Ubuntu 17.04, was released in April 2017. Each regular release is supported for just nine months, by which time you're expected to have upgraded to a newer version (you can upgrade from a previous version by going to "Settings → Software & Updates → Updates tab," and choosing "For any new version" under "Notify me of a new Ubuntu version"). The next major release will be Ubuntu 17.10, released in October; support for Ubuntu 17.04 will end in January 2018.

Every two years, a special version with extended support is released. These Long Term Support (LTS) versions are supported for up to five years. The latest is Ubuntu 16.04.2 LTS (the .2 stands for the latest bug and security fix release).

Each new version of Ubuntu is also known by a codename, using the next available letter of the alphabet. Ubuntu 16.04 LTS is codenamed Xenial Xerus, while Ubuntu 17.04 has been given the name Zesty Zapus. Ubuntu 17.10 will be Artful Aardvark, as the letters reset to A.



Make sure you upgrade to Ubuntu 17.10 when it's released by configuring this setting.

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TECH PORN

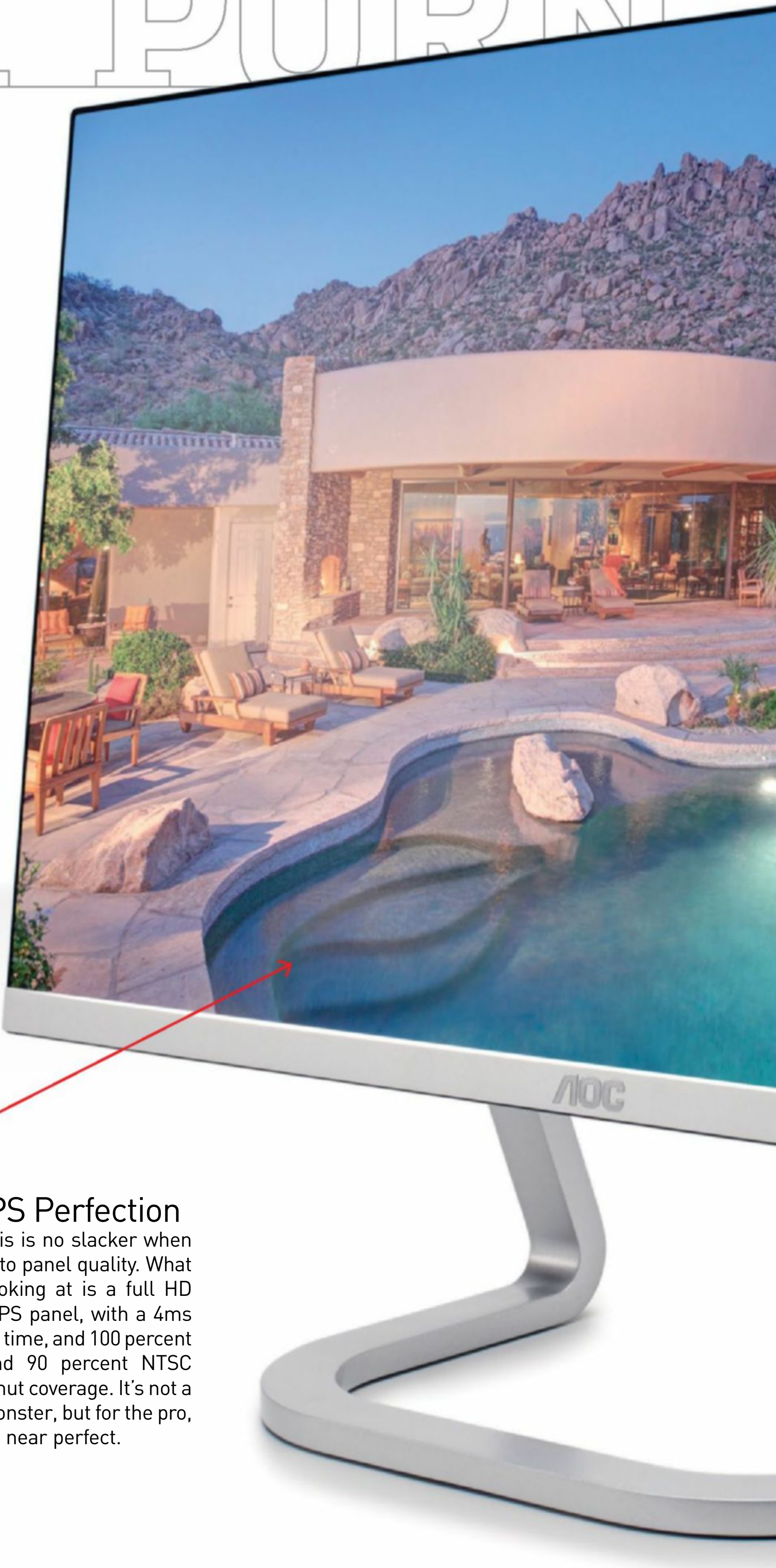
AOC PDS241

THIS SCREEN is truly something to behold. A design unlike any other on the market. Don't let its paltry 1080p resolution fool you—the AOC PDS241 is an absolutely stunning piece of craftsmanship.

As far as AOC was concerned, teaming up with Porsche was a logical move. The supercar company has built a number of bespoke products in the past, and it made sense to have the German firm join in on this professional series of screens, too.

The story of the PDS241's conception is outstanding. According to AOC, Porsche came into its offices, sat AOC's entire design staff down, and schooled them on what the perfect screen should be. According to Porsche, it's a single panel, floating in the air, with no cables, no frame, no bezel—nothing.

It sounds insane at first—both that a car company told AOC how to design a monitor, and the very concept. But from that surprising partnership comes this outstanding and unconventional panel, and who are we to argue with that? –ZAK STOREY



1 IPS Perfection

This is no slacker when it comes to panel quality. What you're looking at is a full HD 24-inch IPS panel, with a 4ms response time, and 100 percent sRGB and 90 percent NTSC color gamut coverage. It's not a 140Hz monster, but for the pro, it's damn near perfect.

3 World's Thinnest

AOC is touting this as the world's thinnest screen. Thanks to the I/O being relegated to a pass-through hub, the LCD panel itself can be made exceptionally thin—just 5.2mm, in fact.

2 Cable-Free?

AOC has done away with the clutter on this beautifully crisp display, by using a pass-through on this sweet curved metal stand. One cable comes out here, fitting into a PSU block with power and HDMI inputs, so you can hide it under your desk.

ROG EDITION 10
RAMPAGE V
REPUBLIC OF GAMERS
RAMPAGE V EDITION 10
ASUS
SupremeFX
PCIEX8_2
PCIEX16/X8_3
PCIEX8_4

PCI EXPRESS EXPLAINED

The PCIe bus does a lot more than run your graphics card—how many lanes you have, and where they are, is crucial. By Chris Lloyd

THERE ARE TWO THINGS going on inside your PC. Data is processed, and data is moved. That's pretty much it, apart from a fan or two. The quest for performance is about getting data to and from the processing silicon. There's a myriad of buses moving that data about, from a sluggish link to the keyboard, where you can almost type at the same speed, to the memory bus, which, for DDR4, starts at 17GB/s and gets faster.

While the internal memory bus has developed alongside CPUs to keep pace, the external or expansion buses have been dragging their feet. The advent of solid-state drives highlighted the bottleneck that storage had become, quickly swamping SATA ports. PCIe emerged rather quietly in 2003, but it took until 2008 before it had replaced the AGP slot, which lingered, then finally died around 2010.

PCIe controllers moved to the processor die, and by version 3.0, it emerged as the high-speed bus for demanding components. By 2012, it had become the primary onboard bus for integrated peripherals and expansion cards. A PCIe controller is running your graphics card, and probably a lot more, including that nice new M.2 slot, and working behind the scenes on some of your USB, network, and SATA ports, too.

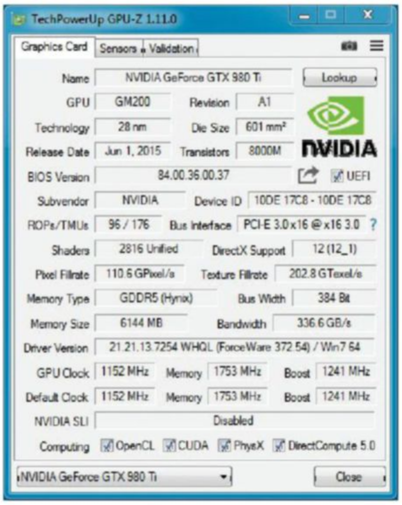
PCIe is the reason multiple graphics cards are so easy. If anything plugged or slotted into your rig needs serious data shifting properties, the PCIe bus is the way to get it. How many PCIe lanes you have, and where they are, is a fundamental part of any system's configuration. You need to know your links and lanes....

THE MAIN DRIVING FORCE behind getting a fast bus for expansion cards is the graphics card. From text to color to high resolution to 3D to 4K, it quickly ate into any available bandwidth like a voracious monster. 1992's parallel PCI bus could manage 533MB/s in top spec; this gave way to PCI eXtended in 1998, which ran to 1,064MB/s, using a modification of the same system. AGP doubled it again to 2,133MB/s, still building on the same model. But the graphics card wanted even more. Despite the similar-sounding name, PCI Express moved to a completely new model, and jumped from a parallel bus to a serial bus.

Hang on, though—parallel is faster than serial, clock for clock, right? Shifting 32 bits of data down 32 wires in one clock cycle is 32 times faster than one bit of data down one wire. Yes, it is—however, AGP runs at a fairly modest 66MHz, and there was little room to go much faster. High-speed parallel buses have some nasty inherent problems. These include time skew or propagation delay. In a parallel system, all the data has to arrive at exactly the same time, or you get mismatched data. The faster you go, the more that minuscule differences in timing can mess things up. At high speeds, even seemingly atomic differences in track length count. Another problem is crosstalk or electromagnetic interference—lots of high-frequency signals together require a lot of grounding and integrity checking, and wide parallel systems have a lot of wires.

These are not insurmountable problems, but a high-speed parallel bus is much easier to implement as an internal bus, where you can control data path lengths and timings, and have a tight rein on what is attached at each end. Add in variable track lengths and unknown hardware, and it gets complicated, which translates as expensive. The PCI parallel model is also horribly inflexible, bandwidth is shared, speed locked to the slowest device, and everything has to be wired to the same width. And there's no way to add extra bandwidth without cranking up the clock or widening the bus.

The PCIe bus replaces the old parallel bus with multiple serial buses, called lanes. Each works as a separate high-speed serial bus, and a controller assembles the data on delivery. Each lane consists of two pairs of data lines—one pair carrying the same signal but with inverted polarity. Thus, if you add the two together, anything left over is noise, and can be discarded. Neat. Add in some data encoding with scrambling, and you are good to go. The latest PCIe 3.1 specification has a speed of 985MB/s per lane—that's a healthy 15.75GB/s on a x16 link. It runs on a base clock of 8GHz; over 120 times faster than AGP.



Name NVIDIA GeForce GTX 980 Ti
GPU GM200 Revision A1
Technology 28 nm Die Size 601 mm²
Release Date Jun 1, 2015 Transistors 8000M
BIOS Version 84.00.36.00.37 ☑ UEFI
Subvendor NVIDIA Device ID 10DE 17C8 - 10DE 17C8
ROPs/TMUs 96 / 176 Bus Interface PCI-E 3.0 x16 @ x16 3.0 ?
Shaders 2816 Unified DirectX Support 12 (12_1)
Pixel Fillrate 110.6 GPixel/s Texture Fillrate 202.8 GTexel/s
Memory Type GDDR5 (Hynix) Bus Width 384 Bit
Memory Size 6144 MB Bandwidth 336.6 GB/s
Driver Version 21.21.13.7254 WHQL (ForceWare 372.54) / Win7 64
GPU Clock 1152 MHz Memory 1753 MHz Boost 1241 MHz
Default Clock 1152 MHz Memory 1753 MHz Boost 1241 MHz
NVIDIA SLI Disabled
Computing ☑ OpenCL ☑ CUDA ☑ PhysX ☑ DirectCompute 5.0
NVIDIA GeForce GTX 980 Ti

GPU-Z reports how many PCIe lanes your graphics card is using, although it can be fooled by cards idling or power-saving.

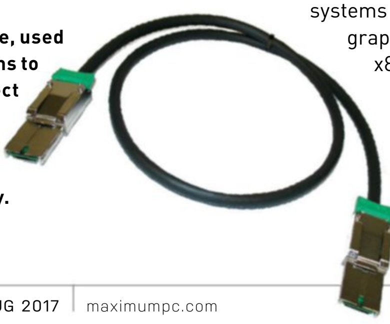
FOLLOW THE LINK

PCIe is a point-to-point system, which means it only connects two devices, and these devices don't have to share any bandwidth with any other lanes. Your rig can assign lanes where they are required, and get them all to run at full whack without concern for any interference from elsewhere. Devices can be assigned with either x1, x4, x8, x12, or x16 links, depending on the number of lanes. The specifications allow for a x32 link, but we've yet to see that outside specialist applications, and a x12 link is rarer than hen's teeth.

On booting, there is a round of digital negotiations between BIOS and devices, as lanes are assigned to devices according to need and availability. It's beautifully scalable—to add more PCIe bandwidth to a system, add more lanes to the PCIe controller. If you need more bandwidth on a card, simply assign more lanes. Magic.

Your motherboard probably has more PCIe connectors and slots than it has free lanes. Two full PCIe graphics cards would theoretically require 32 lanes, but most systems don't have that many free. That x16 graphics card may well be running at x8, and the Wi-Fi card plugged into a x4 connector only gets a single lane, because that's all it needs. Similarly, a slot may be wired for fewer lanes than possible—that third x16 slot may only be wired at x4 or x8. Manufacturers dislike adding anything superfluous; having a close look at the contacts inside a slot often reveals one that isn't wired to full capacity.

This brings the interesting phenomenon of the disappearing ports and lanes. Because lanes can be shared between slots and ports, you can find that things drop off the radar. You happily add a couple of M.2 cards, only to find you've lost some SATA ports, because they were on the same PCIe lanes. Add a card into a x16 slot, and your other x16 card may drop to operating at x8. It's not immediately obvious where your lanes are being assigned without a little investigation. Motherboards tend to advertise the maximum possible of each type of port or slot, but that doesn't mean you can run all at once.



A x4 PCIe cable, used in server rooms to directly connect machines via PCIe. It may escape the box eventually.

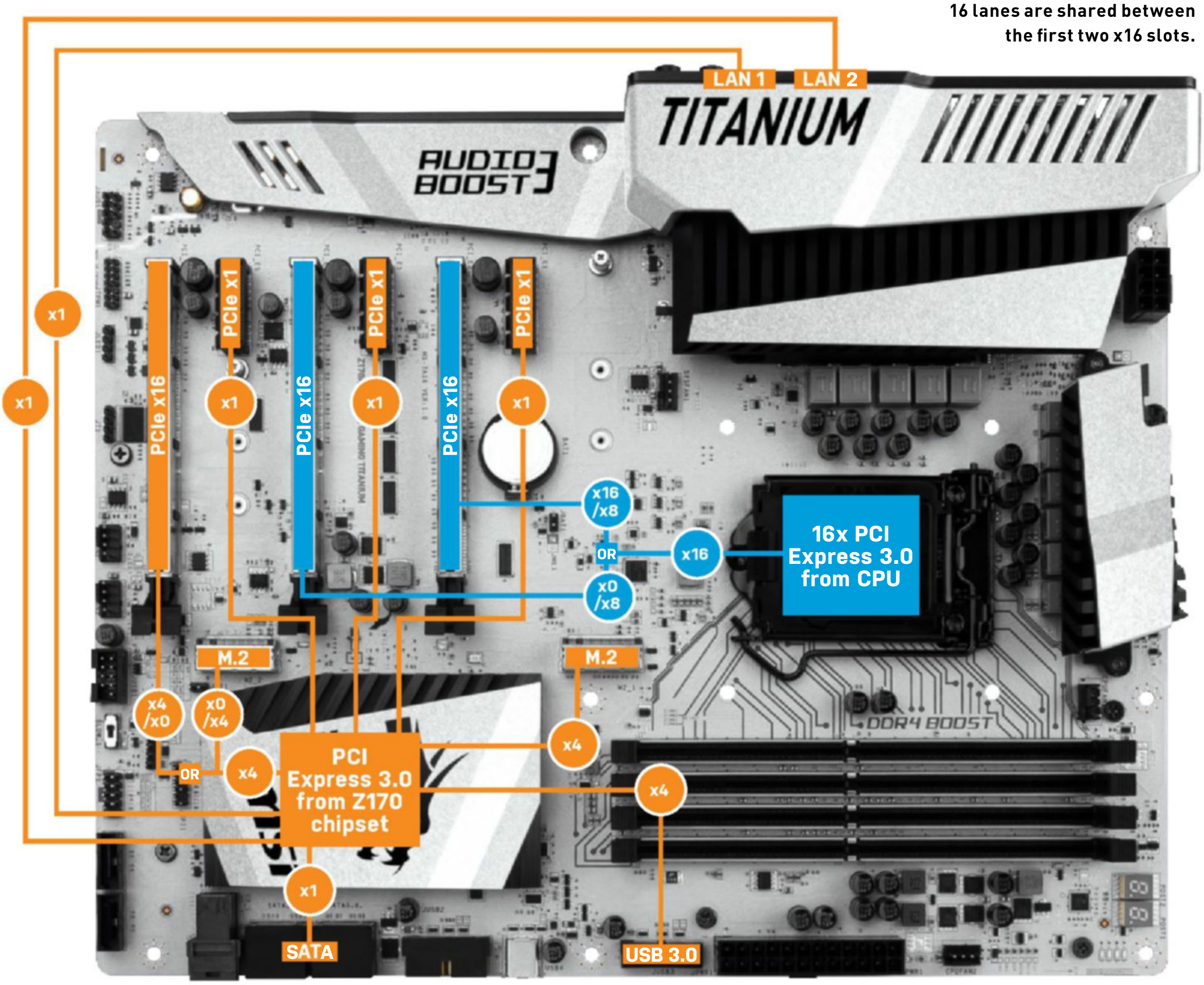
The system does have a refreshing flexibility, however, unlike so much PC gear, which can be annoyingly precise and fussy. If a card can physically fit into a PCIe slot, it runs—you can fit a x1 or x4 card into a x16 slot, and they work the same. Given an open-ended slot, you can even plug a x16 card into a x4 slot, and it happily chugs along at x4. It's compatible forward as well as backward, too. You can plug a PCIe 1.0 card into a version 3.0 board, and vice versa. Devices simply operate at the lower standard. How many lanes any card actually uses depends on the wiring of the slot, the requirements of the device, and the initial assignment of PCIe lanes.

Let's back up for a moment—how many lanes have you got to start with, and which versions? PCIe controllers have two main homes: built into your CPU and on your motherboard chipset. Current Skylake and Kaby Lake chips sport 16 PCIe 3.0 lanes; Broadwell-E and Haswell-E have either 28 or 40. The X99 chipset adds eight PCI 2.0 lanes (about half as fast as version 3.0), the Z170 chipset adds 20 PCIe 3.0 lanes, and the Z270 sports 24. AMD's Ryzen 7 has 24 lanes, although four are lost to the interconnect with the motherboard chipset. The enthusiast X370 chipset adds eight more. CPU-based controllers support up to x16 links; motherboard chipsets currently top out with x4 links.

SHARE AND SHARE ALIKE

Add together the CPU and chipset lanes, and you have the total usable lanes—but this is not a common pool that can be used by all connected devices. Slots have to be physically wired to either processor or motherboard controllers. The PCIe controller on the motherboard chipset has another bus to travel before reaching the processor, too. On an Intel system, that's the DMI link—version 3.0 runs out of steam at a little under 4GB/s, roughly equal to a x4

Lane Splitting *Explained*


LAN 1
LAN 2
TITANIUM
AUDIO BOOST 3
x1
x1
PCIe x16
PCIe x1
x1
PCIe x16
PCIe x1
x1
PCIe x16
PCIe x1
x1
x16 /x8
OR
x16
x0 /x8
16x PCI Express 3.0 from CPU
M.2
M.2
x4 /x0
x0 /x4
OR
x4
PCI Express 3.0 from Z170 chipset
x4
x4
DDR4 BOOST
x1
SATA
USB 3.0

Here we have a Skylake processor on a Z170 chipset with 18 wired lanes. The CPU's 16 lanes are shared between the first two x16 slots.

Special Interest

The basic PCIe specification is handled by a SIG (special interest group) of the big PC players, including Intel, IBM, and around 700 others. The plan was to replace the PCI, PCI-X, and AGP bus (although it looks as though it'll replace more). PCIe 1.0 was nailed down in 2003. It runs at 250MB/s per lane. Version 1.1 brought technical improvements. In 2007, we got version 2.0, which doubled the data rate by simply doubling the clock to 5GHz. Again, this was soon followed by a technically improved version 2.1. PCIe 2.0 first appeared on Intel's X38 chipset, and is still in circulation in the H110, X79, and X99 chipsets.

The current version 3.0 appeared in 2010, and nearly doubles performance again, to 8Gb/s or 985MB/s, thanks to a clock jump to 8GHz, and more efficient encoding. Version 3.1 brought some technical housekeeping. All versions of PCIe have been backward compatible, which is a joy.

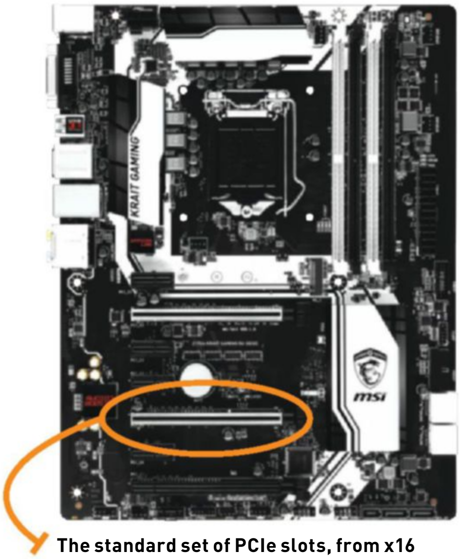
Version 4.0? Not far away now. The specifications were announced in 2011, and again we get a doubling of the data rate. We saw test machines running experimental silicon last year, and were promised it for 2017. However, things have gone a little quiet now. Technically, it has proved harder than anticipated—this sort of data rate down a copper wire is skirting the edge of practicability. There have been no press releases on the PCI SIG website this year at all. If it does appear this year, it will be late; 2018 looks more likely. Luckily, we aren't banging on the limits of version 3.0 yet.

Beyond this, we have talk of version 5.0. Once again, we've been promised alarming data rates of 25 or even 32Gb/s. This used to mean optical, although recent developments in Ethernet technology mean that we may have one more copper, or partly copper, version left.

PCIe bus; AMD has a similar specced bus. It is well worth remembering that everything on the other side of this has to share bandwidth to reach the CPU and memory.

The PCIe controller in your processor handles the x16 slots for your graphics card, and possibly an M.2 slot, while the controller in your motherboard chipset runs other M.2 slots, LAN, SATA, and USB ports, as well as a sprinkling of x1 and x4 slots, and a few other bits and bobs.

That first PCIe x16 slot for your graphics card will be wired as a full x16 slot to the CPU, pretty much universally. Whether or not the second or subsequent ones are depends on the board and chip combination. Often, the first two x16 slots are wired to the same 16 lanes, so if you fill both slots, each is assigned an x8 link—this is the case for X99 Skylake and Kaby Lake boards with more than one x16 slot.



The standard set of PCIe slots, from x16 to x1. These are physical standards—how many lanes are assigned is another matter; boards often have more capacity than lanes.

THE LANE GAME

On any third and fourth x16 slot, again it depends on processor, board, and chipset combo. It may be that one of your x16 slots draws lanes from the motherboard controller, which is potentially slower, and may share lanes with an M.2 slot. Your M.2 slots may also share links with SATA ports. You see the looming problem here? Start adding multiple graphics cards, RAID, and M.2 boards, and you may find not everything gets the number of lanes it would like to operate at full speed, or at all. It all becomes a lot clearer if you have a nice block diagram, which right-thinking motherboard makers include in your manual—although, for some reason, many manage to omit.

When running two graphics cards, you might feel you ought to be running on two x16 PCIe links. Nope—chances are you aren't. That would require a CPU with 32 lanes, which limits you to the top-end Intel chips. It's also something of an overkill—to flood a x8 PCIe 3.0 link is currently pretty difficult. It'll happen, but not just yet. Even using a top card in 4K, it will merely scrape the upper limit of x8 now and again. There is a difference between x16 and x8 performance, but it's in the order of a percentage point, possibly three.

There is much debate and a lot of YouTube excitement on whether you really should insist on a x16 link on both cards. If squeezing a few benchmark points out of a system is your bag, then, yes, you do. In which case, you need that high-end Intel chip, although even the 40-lane version can't do more than a pair of cards at x16. The bottleneck for high-level gaming power isn't the bus for once.

PNY
SAMSUNG
NVMe SSD
960 PRO

ABOVE TOP: **The PNY M.2 board, a physical connection that can use a number of bus standards. NVMe is the one you want.** ***ABOVE:*** **Samsung's 960 Evo M.2 needs PCIe bandwidth to breathe properly, preferably connected to your processor's controller.**

Oh, all right, yes you can overwhelm an x8 link—connect two awesome graphics cards to multiple 4K screens, and you'll see a performance drop of double digits on some games, depending on how they're coded. However, beyond such insane rigs, a x8 link is fine. It's noticeable that Ryzen 7 can't currently support two x16 graphics card links, yet still manages to rock.

FASTER, FASTER

The other device that welcomes PCIe performance is fast storage. SSDs are strangled on SATA. SATA Express offers a x2 PCIe link over a modified SATA connector, but is something of an interim measure, it's gained little ground, and we expect it to die completely shortly. M.2 and U.2 on a x4 link are the way to go. We have a new interface standard to help, too: NVM Express, a logical device interface for non-volatile memory. Unlike SATA, it was designed from the start with flash memory in mind, rather than physical spinning disks.

Legacy SATA and AHCI (Advanced Host Controller Interface—essentially, the SSD flavor of SATA) M.2 drives run to around

Switch-Hitter

Flexible as it is, PCIe has its drawbacks. Being point-to-point means any unused bandwidth stays unused; it can't be re-assigned once the initial links are assigned. Also, adding PCIe lanes without changing motherboards and/or processors is next to impossible. Enter the PCI Express switch chip, found on some high-end boards. It sits on a PCIe link between devices and the controller, turning one end point into multiple end points, and acting as a network switcher, routing data as devices require it. For example, you could split one x4 link on your motherboard's PCIe controller into two x4 M.2 ports, each with an SSD drive. Both drives "think" they have a x4 link. Bandwidth is split between the drives as required—x4 is plenty for an SSD anyway. One PCIe link can be fanned out across a range of ports and connections, all of which act as if they had been assigned exclusive PCIe links.

The ability to fool devices into thinking they have more lanes than are physically available also means you can use configurations that would otherwise be impossible. High-end gaming boards can use a switcher chip, such as PLX's PEX 8747, to run three or four graphics cards at x8 from a single x16 link PCIe controller on the CPU. Or you can fool two cards into acting as if they both had x16 links. Obviously, the total bandwidth is fixed by the PCIe link your switcher is connected to, but you can make full use of the bandwidth across multiple devices. In this case, the cards dynamically share a x16 link—if one wants to run at over x8 performance, it can, as long as there is slack on the second card. It's a neat solution. Apart from a dollar cost, it does add a little latency (100ns or more), which adds a small performance overhead.

A PCIe switch enables you to spread a CPU's PCIe controller across x16 slots as required.

A x4 PCIe card that adds two USB 3.0 ports, easy and cheap. PCIe gives you access to a high-speed bus right across your board.

550MB/s at full pelt. NVMe versions can make good use of the x4 PCIe bandwidth. Samsung's 960 Evo M.2 card runs to 3,200MB/s read and 1,900MB/s write speeds—$250 buys the 500GB version, so not exactly cheap yet, but so inviting. It makes hard drive data transfer rates look positively archaic. Note that this is faster than the X99's PCIe 2.0 x4 link can handle.

Remember: M.2 is a set of physical specifications for internal cards. It can employ a number of bus standards, notably SATA, AHCI, USB 3.0, or NVMe. Just because a card plugs into an M.2 slot connected to a x4 PCIe link doesn't automatically mean it's going to be superfast.

All well and good. NVMe M.2 is great, but the bottleneck is the internal bus between processor and chipset. Your SATA, USB, network, and possibly M.2 slots are all on the "wrong" side of this, which is one reason why the M.2 RAID 0 systems that some poeple excitedly put together when the first multiple M.2 slot boards arrived proved a little disappointing in action—fast for sure, but there's room for much more.

Two NVMe cards will saturate the DMI link, even with everything else running at idle. Look for boards that have M.2 slots wired to the processor's PCIe lanes. However, on a Skylake or Kaby Lake system, that does mean you won't be able to run two x8 link graphics cards. For serious RAID data rates, you need a dedicated controller card running from a x16 slot. This is why processor PCIe lanes are more valuable than chipset ones.

Fast storage is all a bit of a mess right now, with no clear slot for properly fast storage. NVMe M.2 means the bandwidth limits are already in sight, despite M.2 being pretty new. Intel's Optane could certainly use a decent home—it looks like a memory module in search of a socket at the moment.

MANUAL WORK

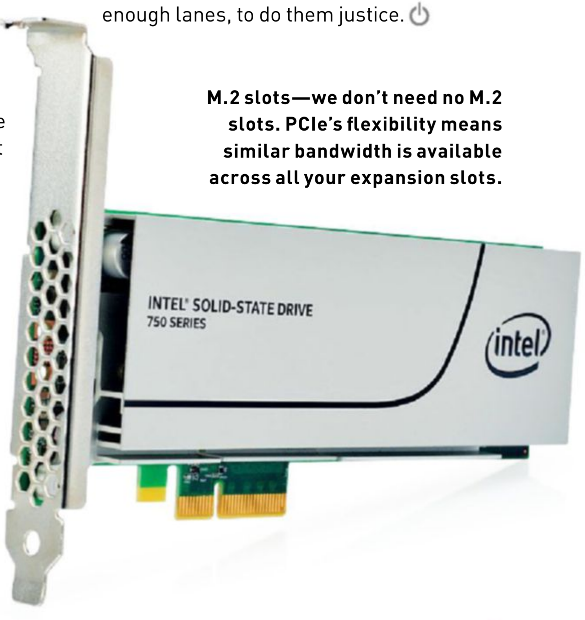
You are not going to like this. Groan if you must, but given the multiple ways a motherboard can be wired, you need to read any prospective board's manual very carefully. Yes, we went there: Read the manual. It's the only way to be sure of what is wired where. Flexible systems lead to multiple options which, unfortunately, means no standards. Specifically look at how the x16 slots are wired, and where the M.2 slots get their lanes, and what ports these are shared with.

PCIe is a huge technical jump over previous buses. Splitting down the data into lanes is brilliant, and having lots of PCIe lanes is certainly a good thing. Is it worth springing for a Broadwell-E or Haswell-E chip to get them, though? You can run a very tasty rig on just 16 processor lanes. However, if you plan to explore the limits of NVMe or RAID, and want to run multiple graphics cards at their absolute best, then you'll always find a good use for those extra lanes.

There is a reason why Intel charges an extra $200 for an i7-6850K over an i7-6800K, despite having the same core, and clock speeds that are within spitting distance of each other: The 6850 has another 12 PCIe lanes on the core. That's what Intel thinks they are worth, or rather it's what it thinks it can charge you for them.

It may not quite be the one bus to replace them all and in the darkness bind them, but PCIe does bring long-overdue data rates that rival internal buses to the expansion card and to storage. You need to think about PCIe lanes and controllers right from the start of speccing out a rig. Buses aren't as sexy as graphic cards and overclocked CPUs, but PCs are all about moving data, and PCIe provides a flexible and scalable bus that can cope. It's impressive—just make sure that you've got things plugged into the right slot, and have assigned enough lanes, to do them justice.

M.2 slots—we don't need no M.2 slots. PCIe's flexibility means similar bandwidth is available across all your expansion slots.



HSIO Lanes

To complicate things further, Intel has High Speed I/O lanes (HSIO). These appeared on its 1xx and 2xx series motherboard chipsets. They're a development of the Flexible I/O system on the X99, which enabled selected PCIe lanes to be used to run SATA or USB ports instead. As the name says, they are high-speed internal lanes that are used to connect all the PCIe lanes; one HSIO lane per PCIe lane. But they're also used for SATA, USB, network, and other gear. Every non-PCIe device is going to eat into your HSIO lanes. Some rough math tells us you can't connect nearly as much gear to a Z170 board as you might think.

The Z170 chipset has 26 HSIO lanes and 20 PCIe lanes. The first six HSIO are fixed to running USB 3.0 ports. This leaves everything else to share the 20 of each left. If you fill your SATA, USB, and GbE ports with hardware, you have nine motherboard chipset PCIe left. It's not very flexible either; specific HSIO lanes are tied to specific ports. If you have a storage device that needs four PCIe lanes, you have three possible blocks of HSIO lanes it can use. These are also assigned to your SATA ports. A second M.2 board will cost you two SATA ports, a third will cost you all six.

The Z270 chipset has 30 HSIO lanes, similarly configured. Your board may also sport companion controllers that add more ports or variations. While there are some decent technical arguments behind using HSIO—it brings all your high-speed ports together, and means board manufacturers have lots of options—it does undercut some of the flexibility.

Storage devices can use HSIO, but it isn't very flexible.

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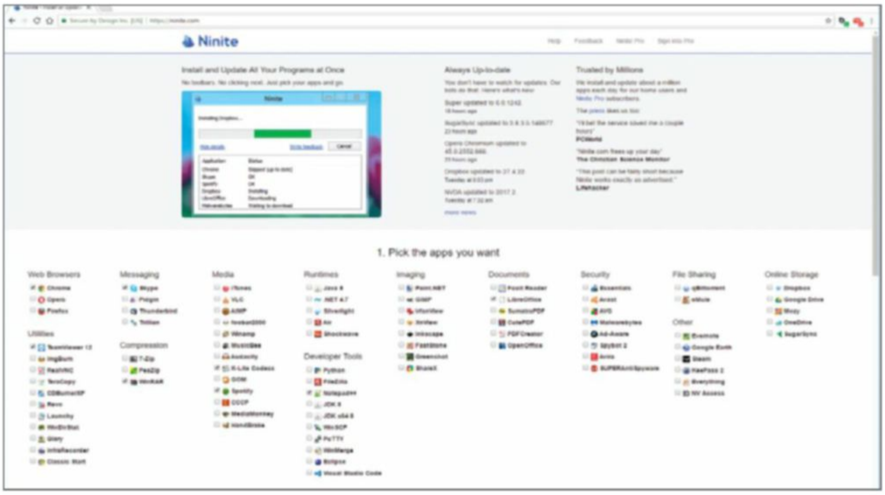
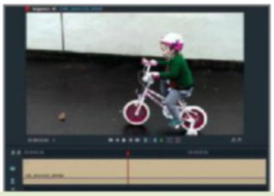
TIP OF THE MONTH



INSTALLING A FRESH OS

It's been a while since we've spoken about Ninite, but we still use it regularly. Building a new system, and want to cut the hassle of installing all your favorite programs? Head to http://ninite.com, select the apps you want, download the installer, and let it run. There's no spam—Ninite makes its money through a paid premium version, which keeps your apps up to date, and operates across multiple corporate ecospheres.

MAKE – USE – CREATE



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Turn your home video pro with Lightworks

70
Find out how to fake a 360-degree photo for Facebook

72
Build a new office workhorse by reusing old hardware

ZAK STOREY
REVIEWS EDITOR

A GOOD FRIEND

I officially started working here in early 2015. After 66 different job applications (journalism is tough to get into), I finally made it. But not without a lot of help.

Just prior to joining, my interest in technology was waning. I was an avid gamer and overclocker, but the stress of finding work began to take its toll, and cycling relieved the pressure.

What brought me back to the path of the righteous transistor was a good friend of mine, another journo student. We started a community-led social media news platform, and managed over 16 volunteers, writing games news and reviews, and even developed our own website. When the opportunity to work for *Maximum PC* popped up, with his encouragement I jumped at the chance. I left the project, but with the promise that one day I would get Jacob writing as a freelancer with us as well.

I never got around to organizing freelance. A promise I'll never be able to keep as he sadly passed away in May. He was astonishing: witty and sharp, with a keen mind, and a sense of OCD and competitiveness that rivaled my own. Without him, I wouldn't be where I am today, and I'll be forever grateful.

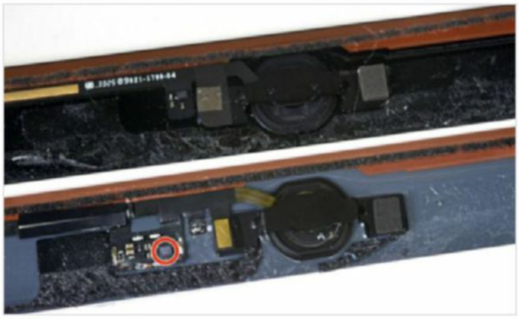
The PC enthusiast community brings people together in a way that no other medium ever has. People from all over the globe can meet, chat, become friends, learn, all thanks to the tiny transistors in your phone, tablet, or computer. It's something we should never take for granted.

↘ submit your How To project idea to: comments@maximumpc.com presents:

AUTOPSY

THIS MONTH WE DISSECT…

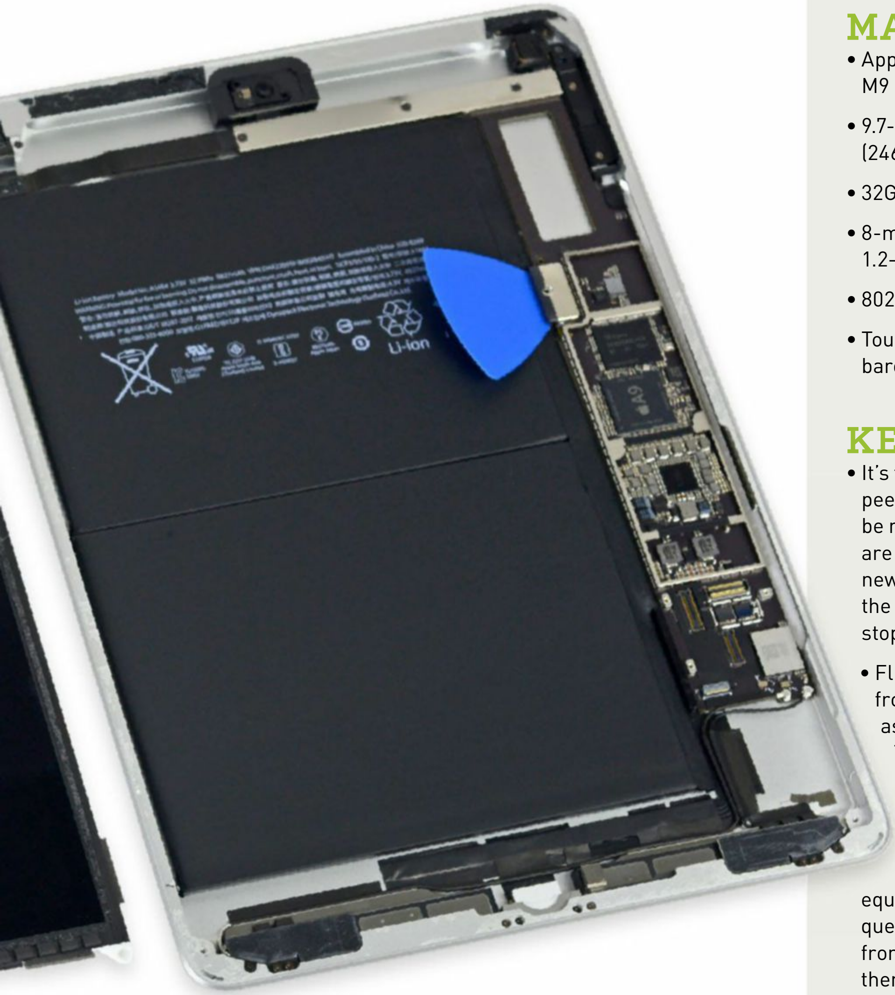
Apple iPad 5



Well, at least there's one thing that's different.

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.



BACKGROUND

The iPad team took a page from the iPhone SE playbook, and released what appears to be a throwback—an arguably under-specced tablet that takes aim at the education and enterprise markets. This iPad is supposedly reasonably priced, and powerful enough for professionals—but will it also earn high marks for repairability? Let's find out.

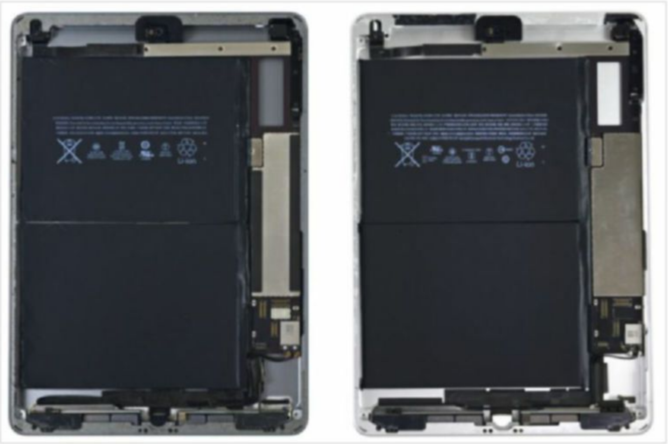
MAJOR TECH SPECS

- Apple third-generation 64-bit A9 processors, with embedded M9 motion co-processor
- 9.7-inch multitouch Retina display, with 2048x1536 resolution (246 ppi), and non-laminated digitizer
- 32GB or 128GB of storage
- 8-megapixel 1080p rear-facing iSight camera, plus 1.2-megapixel 720p front-facing FaceTime HD camera
- 802.11a/b/g/n/ac MIMO Wi-Fi and Bluetooth 4.2
- Touch ID fingerprint sensor, three-axis gyro, accelerometer, barometer, and ambient light sensor

KEY FINDINGS

- It's time to start the iPad opening song and dance: Heat, pry, peek, repeat. Based on early reports, we're expecting this to be more Air 1 than 2—and this is why: The LCD and digitizer are unfused, and can be replaced separately. This is great news for repair. We needle a battery isolation pick betwixt the battery contacts and logic board to prevent any mishaps, stopping those electrons in their tracks.
- Flipping the digitizer over reveals the biggest change so far from the lookalike iPad Air: the addition of Touch ID, and its associated hardware. Thumbs up for fingerprint reading. Thumbs down for a harder repair, because the sensor is uniquely paired to its logic board at the factory.
- Moving on to the display, we don't spy any convenient manufacturer marks this time around. In Apple's press release announcing the iPad 5, it told us it comes equipped with a "brighter 9.7-inch Retina display." Our question is: Brighter than what? It doesn't look that different from the Air 1's display. If they mean brighter than the Air 2, then that may simply be due to reverting to the unfused display design of the Air 1.
- So, remember how we said this was similar to the first Air? We were serious—take a look at the photos on the left of the Air 1 and iPad 5. Not much has changed. Here, the Air 1 is dressed in space gray, and has a slightly larger Wi-Fi module. The iPad 5 is in silver, and... has less tape? They both pack the same 32.9Wh battery, beating the 27.6Wh iPad Air 2 and the 27.9 Wh iPad Pro 9.7-inch (all of which are outpaced by the Surface Pro 4's 38.2Wh reservoir).
- Repairability Score: 2 out of 10 (10 is easiest to repair). The LCD is easy to remove once the front panel is separated from the iPad, and the battery is not soldered to the logic board. We'll give it that. As in previous iPads, the front panel is glued to the rest of the device, increasing the chances of cracking the glass during repair. Adhesive holds everything in place. As with the Air 1, this ranks among the most difficult battery removal procedures we've seen in an iPad. The LCD has foam tape adhering it to the front panel, increasing the risk of shattering it during disassembly. You can't access the front panel's connector until you remove the LCD.

They may as well be twins.



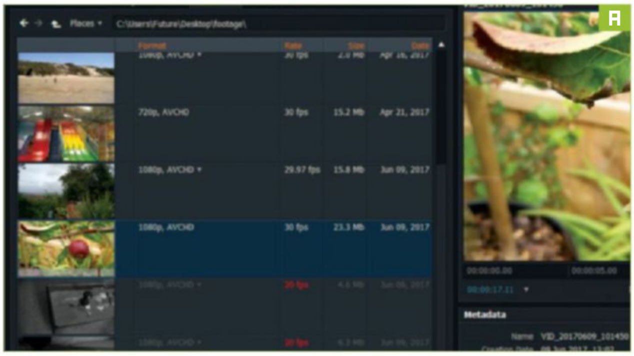
Turn Home Video Pro with Lightworks

YOU'LL NEED THIS

LIGHTWORKS 14
Download from www.lwks.com.

IT'S TRULY AMAZING WHAT WE ALL CARRY IN OUR POCKETS. Never forget that your cell phone is a modern marvel, packing in a closet's worth of tech and tools, particularly when compared to the equivalent from 20—even 10—years ago. And it's great for on-the-fly productivity: Complete albums have been made from scratch on cell phones; people have written novels and scripts; and, to get to the point, entire movies have been shot on iPhones, and received cinematic releases. So, that's one piece of the puzzle—you have everything you need to collect footage.

To splice it, tweak it, and give it that professional shine, why not lean on a tool that's legitimately been used to put together Hollywood blockbusters? Lightworks, matured for 25 years in the movie industry, was part of the toolchain that produced the likes of *Pulp Fiction* and *The Wolf of Wall Street.* Its basic version is available for nothing, and while this free edition lacks a few more advanced features, it's still plenty powerful, and there's lots tucked away in its interface that'll change the way you make home movies in the future. **–ALEX COX**



1 INSTALL AND COLLECT

It's the first step—you know what that means: Download Lightworks from www.lwks.com, and get it installed. It pulls in any dependencies, such as Visual C++, for you, so you can get away with just clicking "Next" until you're done. There's a step that asks you to assign a machine number, but this is only really relevant if you're running multiple editing stations, so leave it at "1."

» Now is also a good time to collect your footage together into a single folder, presuming you've already taken it. If not, film at the highest resolution you can, and be aware that while we'll take some steps to improving the end product, there's nothing Lightworks can do to make bad footage good—check your focus carefully, try to keep your camera steady, and do arty things, such as blurring the background, in-camera, rather than presuming you'll be able to rely on software.

2 FIRST STEPS

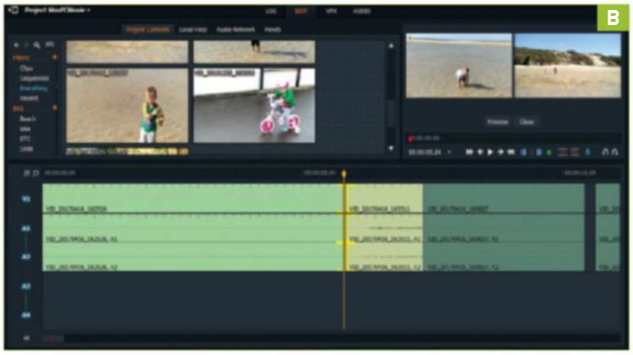
Oddly, Lightworks didn't install a "Start" menu shortcut on our test machine, so you may have to hunt its executable down in the "Program Files/Lightworks" folder to get it running. Click "Create a new project" on the initial splash screen, give it a name, then select the frame rate. This needs to match the frame rate of your footage, unless you want it sped up or slowed down; if you have footage with mixed frame rates or odd codecs, try a tool such as EyeFrame (https://eyeframeconverter.wordpress.com) to normalize it before importing. Alternatively, you can opt for a mixed rate project, but standardizing everything is a far better option. Click "Create" when you're happy.

3 INSERT VIDEO FILES

Lightworks opens to its project management window, labeled "Log." Assuming you've collected your footage together in a single folder, head to the "Local files" link at the top of the window, and navigate to that location. Video that's not compatible with your project is grayed out—check the red markers in the info columns to discover why it won't work. In this case, we've slipped some 20fps footage into our folder for a 30fps project [**Image A**]. Double-click any file to both open a preview in the right-hand pane, and add it to your working library of clips, which can be found under "Project Contents." This can be further sorted into bins, if you're working with a lot of clips. Click the plus icon next to "Bins" on the left, enter a name, then drag videos from the "Clips" folder into the appropriate bin. This is all non-destructive; it just keeps you organized. If you're seeking inspiration or something particular for your movie, you can use the top links to dig through the Pond5 and Audio Network libraries of pre-cleared music, sounds, and stock footage, though this usually incurs a fee.

4 CUT AND SPLICE

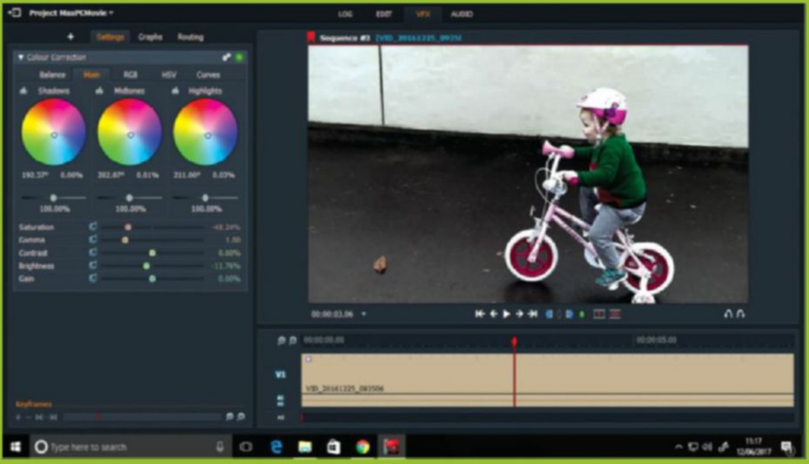
Click "Edit" at the top to enter the editing suite. The footage you pulled in is in the top-left pane. Drag a clip into the bottom pane, and you add it to the current sequence. Drag another clip into the timeline overlapping it [**Image B**], and you've created a basic cut between them; grab the red transport control line, place it at the start of



COLOR GRADING

Although image sensors in cell phones are pretty damn good these days, many of them can't quite get the color right. Lightworks offers up a host of tools to correct this, most of which are best applied to clips individually. Head to the "VFX" window, and begin by adjusting the overall RGB curve of your clip to give it slightly more contrast, then look for any colors that are blown out or oversaturated—you can pull these down a little either by using individual curves or in the RGB panel.

When you're happy with each clip, an overall color caste will give your whole sequence that Hollywood "everything is murky" final touch. Use the wheels in the "Main" window to tweak the shadows, midtones, and highlights to match the particular feel you are going for, then drop the saturation right down, and lower the brightness slightly, to get that neutral, gloomy feel that movie editors seem to love so much. Unfold the effect from the clip you're working on, and then drag it to cover your whole sequence to add consistency.


Project MaxPCMovie
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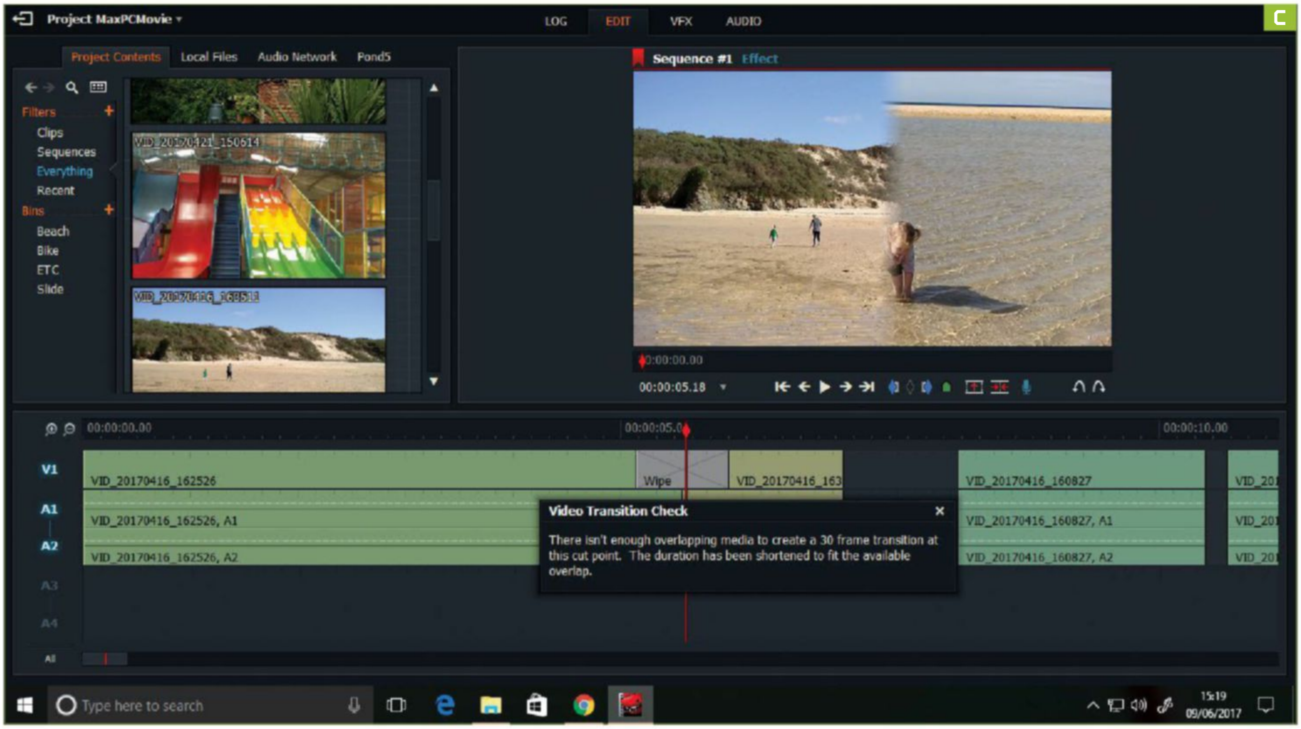
VFX
AUDIO
Settings
Graphs
Routing
Colour Correction
Balance
Main
RGB
HSV
Curves
Shadows
Midtones
Highlights
Saturation
Gamma
Contrast
Brightness
Gain
Keyframes
Sequence #1
V1
Type here to search

your timeline, and hit "Play" (or drag the transport control) to see a preview of what you've just done. We're working non-destructively, so your original clips won't be affected by anything we do from here on, and you can treat sequences in exactly the same way that you'd treat individual clips when you're compiling your final video.

5 TOP AND TAIL

Let's delve a little deeper into Lightworks' editing interface, which is probably the most easy-to-comprehend video editor we've ever worked with. Hover your mouse over the end of a clip in its timeline, and you'll see the edges of the video and audio portion light up white; drag this to trim the clip, or lengthen a pre-trimmed clip. Hover over a transition so that the end of one clip and beginning of another are highlighted, and click. With both elements now highlighted yellow, you can drag this transition to affect precisely when the cut takes place, leaving each individual clip in exactly the same place; if you'd rather move the clip, deselect everything, and simply drag it. Double-click the beginning of a clip and drag, and you move that and subsequent clips, keeping the original transition point and any transitions you've made after it. If you want to edit video independently from audio, deselect


C

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Local Files
Audio Network
Pond5
Filters
Clips
Sequences
Everything
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Bins
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Sequence #1 Effect
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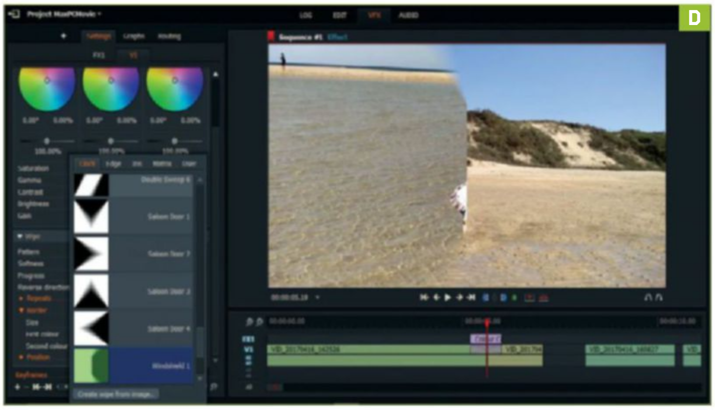
VID_20170416_163
VID_20170416_160827
VID_20170416_162526, A1
VID_20170416_162526, A2
VID_20170416_160827, A1
VID_20170416_160827, A2
Type here to search
15:19
09/06/2017

Video Transition Check

There isn't enough overlapping media to create a 30 frame transition at this cut point. The duration has been shortened to fit the available overlap.



the track you're not interested in by clicking its title on the left of the timeline. A few minutes of play, and it's a second-nature interface.

6 GOING BETWEEN

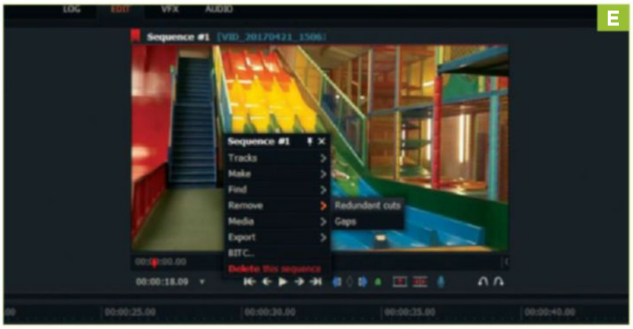
Straight cuts are the most frequent tool you'll use to splice your clips together, but they're by no means your only option. Overlap a couple of clips, right-click the intersection between them on the video track (the uppermost of the three, labeled "V1"), and click the "Add" button below "Transitions" to see a selection of five basic effects, which can be applied between clips. Select one—we favor the *Star Wars*-esque "Wipe" move—and it's added as a new element. The default length is 30 frames; if there's not enough overlap, Lightworks shortens the transition [**Image C**], and lets you know. Transitions can be tweaked just as you'd alter a clip, so you can reposition them, or drag their edges to lengthen or shorten them. You can't add a transition to the beginning or end of a transition (that would be mad), but if you want to try a different effect, you can right-click and replace it with something else, delete the transition and start over, or select "Settings" to go a bit more in-depth.

7 TRANSITION SETTINGS

Tweaking the settings of our transition takes us on our first foray into Lightworks' VFX editor. Ignore the color grading options for now, and look at the lower portion of the left window [**Image D**] to find the controls specific to your transition. If you've chosen the wipe, for instance, you'll find pattern options—bear in mind that the default has been selected, because it's by far the most tasteful, so don't go too mad here—as well as sliders, which affect the specific variables of the transition. If you'd like these to change over time, look for the pie chart icon to the left of individual sliders, which makes that particular setting respect keyframes. You get two by default, at the start and end of your transition, and you can add a new keyframe at the current transport point by clicking the "Plus" button, and reposition it by dragging. Click one keyframe, adjust a linked slider, and repeat for each one—if you now drag the transport control, you'll see the slider change, proportionally, over time.

8 MORE TRACKS

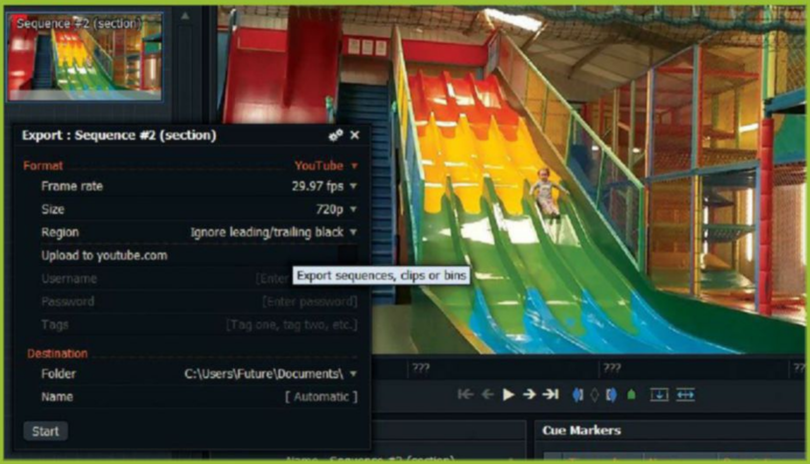
Before we turn our mobile footage into gorgeously graded movie gold, which is surely what you've come for, let's bury the lede even further, and show you a final few timeline tips. Head back to the "Edit" window, and right-click the preview window above, to bring up a list of actions you can perform on the current sequence. This is where you can add new video tracks and audio tracks—though it's often much easier to edit individual sequences with a single set of tracks, so think carefully as to whether you need this. Check out the "Remove" submenu [**Image E**], which is handy if you're just sketching out a sequence: You



EXPORTING FOOTAGE

Lightworks' basic edition supports all kinds of footage when it comes to editing, but getting it out the other side is another matter: You're stuck with 720p Vimeo- or YouTube-suitable output. Frankly, though, if anyone is expecting you to share your home movies in 4K at 120fps, they're probably not going to be on your list of preferred friends for long.

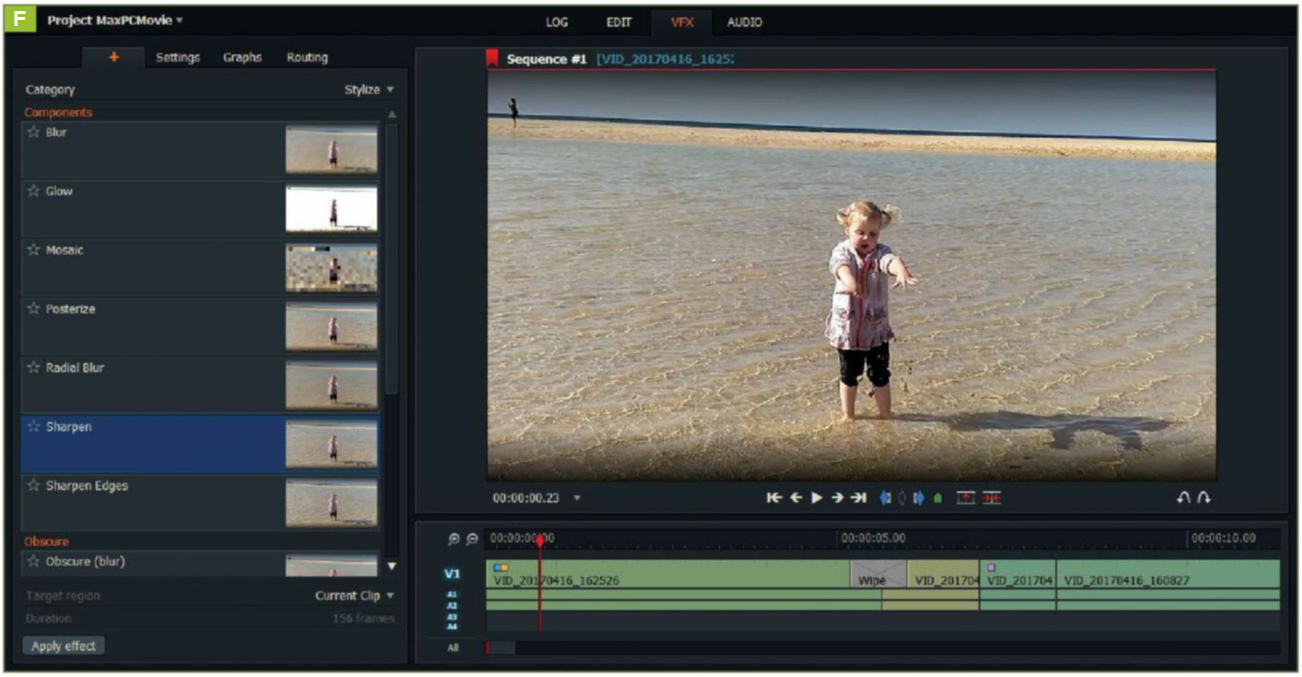
To output your footage, head to the "Log" window, right-click the sequence you want to save, hover over "Export," and select "Vimeo" or "YouTube." There's not much here in the way of complex options, but doubling up your frame rate may lead to smoother footage when exported. You can, if you wish, enter relevant account details, and automatically upload your footage, but hitting "Start" at the bottom of the export window and saving it is a more flexible option. Lightworks renders your clip in the background (meaning you can keep working on other things), and pops up an alert when it's done.



Export : Sequence #2 (section)

Format: YouTube
Frame rate: 29.97 fps
Size: 720p
Region: Ignore leading/trailing black
Upload to youtube.com
Username: [Enter
Password: [Enter password]
Tags: [Tag one, tag two, etc.]

Destination
Folder: C:\Users\Future\Documents\
Name: [Automatic]


F
Project MaxPCMovie ▾
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EDIT
VFX
AUDIO
+
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Graphs
Routing
Components
Blur
Glow
Mosaic
Posterize
Radial Blur
Sharpen
Sharpen Edges
Obscure
Obscure (blur)
Apply effect
Sequence #1 [VID_20170416_1625:
00:00:00.23
00:00:00.00
00:00:05.00
00:00:10.00
V1
A1
A2
A3
A4
All
VID_20170416_162526
Wipe
VID_201704
VID_201704
VID_20170416_160827

Category Stylize ▾

Target region Current Clip ▾

Duration 156 frames

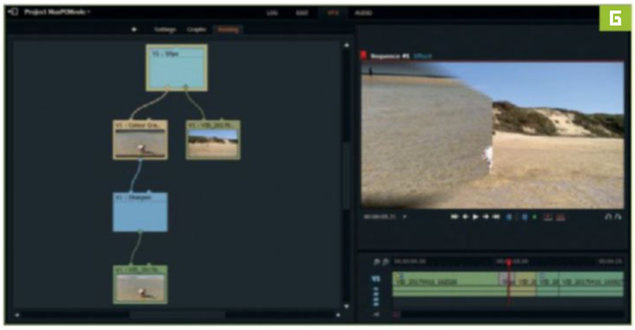
can use it to automatically trim out any gaps in your timeline or remove unnecessary cuts. Speaking of which, splitting a track on the timeline requires a bit of roundabout trickery. Below your preview, you'll see two blue buttons, which enable you to mark the start or end parts of a section of footage for trimming purposes. Clear all your markers (if necessary) by clicking the button between them, then move the transport control to the exact point you'd like to split. Insert an in mark, then click one of the red delete buttons to split the track—essentially deleting a zero-pixel-wide section, leaving the clip in two parts.

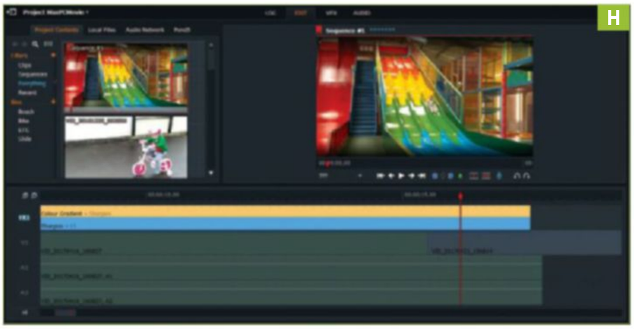
9 BEAUTIFY IT

Once you've finished your editing job—and we're very aware that this is a "draw the rest of the owl" kinda statement—it's time to add some flair. Lightworks has a massive bag of visual effects to choose from, and they're hidden, like its transitions, behind some fairly unassuming menus. You need to apply effects to a single clip to begin with, so, in the edit suite, move the transport control to the clip you want to work with, then hit "VFX" at the top to jump to the effects suite. Hit the plus button (top-left) to see your favorites list, which is sparsely populated by default, and use the drop-down list at the top-right to pick from categories. Some of these, such as Key, Mix, and Matte effects, are only really applicable if you're layering up multiple video tracks; some, such as those in the "DVE" menu, are reminiscent of cheesy effects from the mid-'80s, and should be avoided at all costs. Head to the "Stylize" window instead, and select a Top and Bottom vignette, then add another effect on top: a Sharpen—perfect for getting that cell footage looking crisp [**Image F**].

10 SMOTHER IT

Once you've tweaked the settings of each filter to your liking—the relevant sliders appear in the left column of the VFX interface, and can be keyframe linked in the same way as linking transitions, or rearranged in the routing panel [**Image G**]—you may wish to apply them to your whole movie. Much like every other element in Lightworks, effects are treated as objects of their own, although when first applied, they're tucked away—or, in Lightworks terms, folded in. Right-click the clip you're editing, and click "Unfold." The effects you just added appear in a new timeline track, "FX," and can be manipulated in the same way as any of your timeline elements. Stretch out the track to cover your whole sequence [**Image H**] for a uniform effect, and combine this with color grading—see boxout—for a truly pro finish. There are no limits here. You can safely apply effects to individual clips, then place others over the top; be frugal, though, as it's easy to over-process your footage, and take it from looking classy and clean to terrible and unwatchable. If you've crossed the line, right-click the effect on the "FX" track of your timeline, and use the remove options to take out the culprit. ⏻





Turn Videos into Looping GIFs

YOU'LL NEED THIS

VIDEOPAD VIDEO EDITOR

Grab the free version from www.nchsoftware.com/videopad.

GIF-WORTHY VIDEO

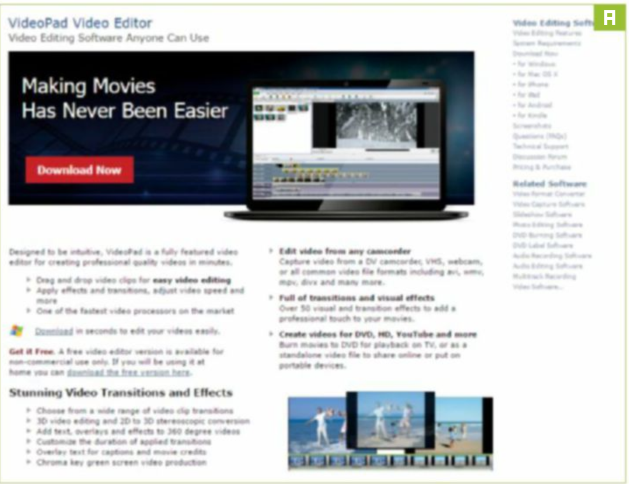
Needs to be short and sweet.

A BASIC WORKSTATION PC

Yes, your quad-SLI rig will do, too.

GIFS ARE THE LIFEBLOOD OF THE INTERNET. Without them It would be a whole lot harder to digest all the times someone fell over at an inopportune moment, or convey a reaction to something using a reality star's facial expressions. The humble GIF's abundance across the Internet is testament to the ease of its creation, but with so many different browser-based options and apps dedicated to the process, it's easy to get overwhelmed.

Not so with this guide. Using the surprisingly powerful free video editing program VideoPad, you're empowered to make a looping GIF with minimum hassle, while retaining control over parameters that browser-based services, such as Giphy, strip away in the name of convenience. Different social media platforms display GIFs at slightly different dimensions, for example, so it's useful to be able to change your GIF's resolution, frame rate, and play speed. It's also good to have a few options when you want to cut down the overall length—no one wants to sit and watch your two-minute magnum opus load, after all—so opting for a program such as VideoPad over a "paste your video link" service is an especially wise move. Now, dig out your best cat videos. –PHIL IWANIUK



VideoPad Video Editor

Video Editing Software Anyone Can Use

Making Movies
Has Never Been Easier

Download Now

Designed to be intuitive, VideoPad is a fully featured video editor for creating professional quality videos in minutes.

- Drag and drop video clips for **easy video editing**
- Apply effects and transitions, adjust video speed and more
- One of the fastest video processors on the market

Download in seconds to edit your videos easily.

Get it Free. A free video editor version is available for non-commercial use only. If you will be using it at home you can download the free version here.

Stunning Video Transitions and Effects

- Choose from a wide range of video clip transitions
- 3D video editing and 2D to 3D stereoscopic conversion
- Add text, overlays and effects to 360 degree videos
- Customize the duration of applied transitions
- Overlay text for captions and movie credits
- Chroma key green screen video production

- **Edit video from any camcorder**
  Capture video from a DV camcorder, VHS, webcam, or all common video file formats including avi, wmv, mpv, divx and many more.
- **Full of transitions and visual effects**
  Over 50 visual and transition effects to add a professional touch to your movies.
- **Create videos for DVD, HD, YouTube and more**
  Burn movies to DVD for playback on TV, or as a standalone video file to share online or put on portable devices.

Video Editing Soft

Related Software

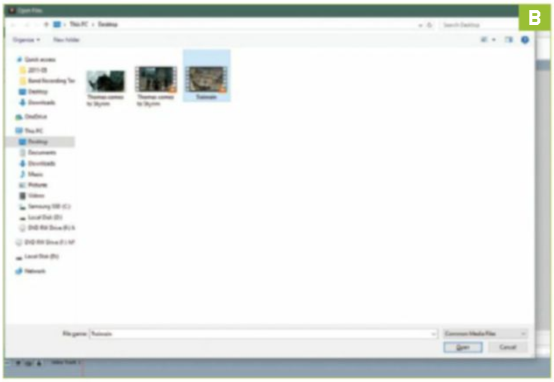
1 DOWNLOAD VIDEOPAD

If you're already in possession of a paid, industry standard video editing suite, such as Premiere Pro, it will come as absolutely no surprise to hear that you already have the prerequisites for making a looping GIF. If you don't, we think NCH Software's VideoPad (www.nchsoftware.com/videopad) is the best option. There's a free version available for non-commercial use, so unless you're thinking of starting a business whose sole product is Taylor Swift reactions, go for that [Image A].

›› There's obviously a whole bunch of video editing programs available for free, but what we like about this one is that, as far as we can see, none of the features you'd ever want are pushed behind a paywall. While some programs limit your export options, or skimp on effects, you get the full suite here, with minimal annoying, cap-in-hand, pop-up messages. We also like the similarity to Premiere Pro's layout—similar free programs, such as OpenShot, are powerful, but their UIs can take a long time to get used to.

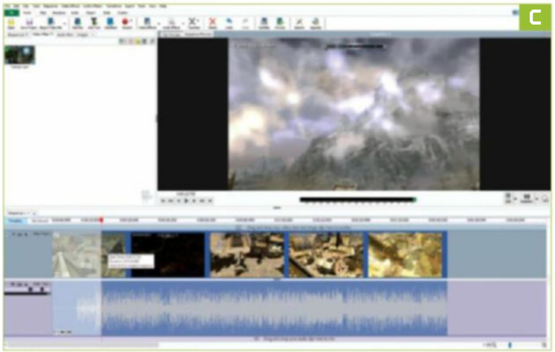
2 SELECT AND IMPORT YOUR VIDEO

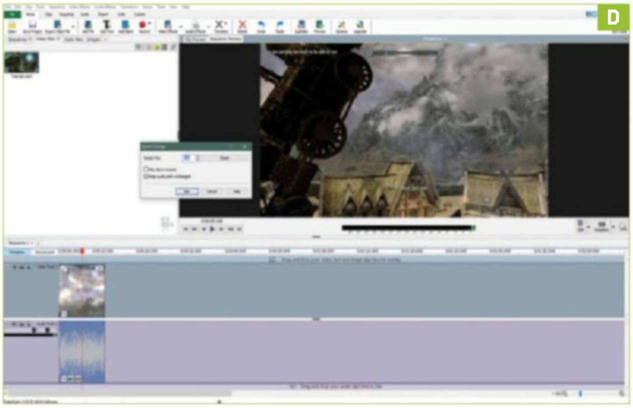
Open VideoPad, and select "Open project" when prompted. Navigate to the location of the video you'd like to turn into Internet gold, and select it [Image B]. You'll see it appear in the left-hand box, or "video files bin," and a video preview should also appear on the right. Alternatively, you can simply select "New project," and manually drag a video file into the video files bin. It's now sitting patiently within the program, ready for you to start editing.



3 TRIM IT DOWN TO SIZE

Beneath the video files bin and preview window, you'll see two timelines: video above, and audio below. Drag your file into the video timeline, and you'll see they both populate [Image C]. It's here that you'll select the start and end points of your GIF. To do so, drag the red





marker along to where you'd like the GIF to begin, then move the cursor back to the beginning of the file, until you see it change to a square bracket. Then click and drag it over to where you just placed the red marker—you'll see it "snap" to that point, and when you release, you'll have trimmed the start point. Set the end point by moving to the end of the file, clicking when the square bracket appears, and dragging to your desired point on the timeline. If you're scrubbing through a particularly long video, you can adjust the zoom in the bottom-right corner for convenience. Hit the play button in the preview window to see how the newly trimmed version looks—you can drag the beginning and end points around if you didn't nail it first time.

4 CHANGE CLIP SPEED TO TASTE

GIFs aren't about testing the limits of the human attention span, so the briefer the better for your content. If you've hacked out all the boring bits either side of the part you want to use in your video, but it's still running long—long being anything over five seconds in GIF land—you can shrink it further. Go to the "Video effects" drop-down menu, and select "Change clip speed" [**Image D**]. You can be quite brutal with the numbers here—don't be afraid to boost it past 200 percent play speed. It takes a while to render at higher play speeds, though, so be patient.

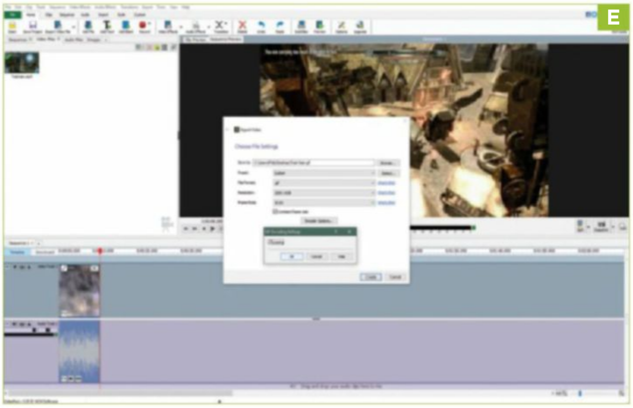
5 INTRODUCE SOME EFFECTS

If you're feeling creative, head back to the "Video effects" drop-down menu, and play around with some of the effects. There's a lot to experiment with, which is a pleasant surprise for a free program—although, like the clip speed change, each effect has an impact on rendering time. Layering them prompts a particularly strenuous workout for your PC.

6 EXPORT YOUR GIF

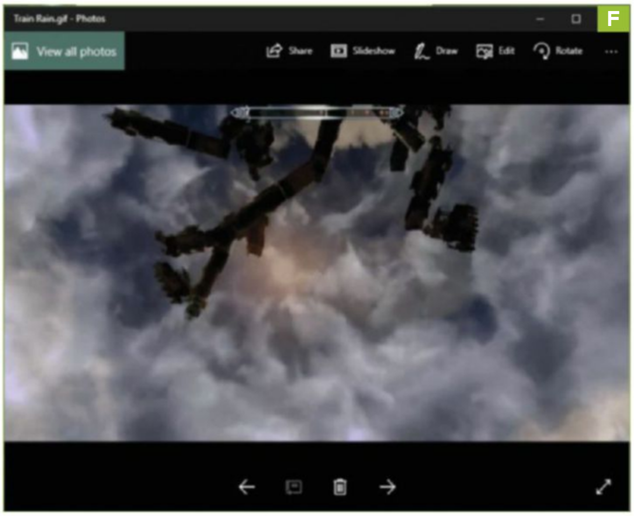
Now it's time to turn your tiny masterpiece into a shareable, looping GIF. To do so, select the "Export" drop-down menu, then hit "Video file." In the next menu, choose the .gif file format, and choose your frame rate. Lower is better, because it makes the file size smaller, and the GIF faster to load; 15–20fps is usually adequate. Check the "Constant frame rate" box for smooth playback, and enter ‘"Encoder settings" to enable the "Looping" checkbox in the menu within [**Image E**].

» Bear in mind that Facebook prefers a 1200x628 resolution, and Twitter likes 1024x512—you can set a custom resolution for your intended platform. Once you've chosen where you'd like the file to export to, you're all set.



7 TRY IT OUT

Your newly created GIF should autoplay in web browsers and Microsoft Photos [**Image F**]. Now's the time to check for artifacts or messed-up exports. If you needed to crop the image during the export process, it's also worth checking that everything important is still in shot. If it's all playing as planned, though, you're ready to take social media by storm. ⏻



BROWSER-BASED ALTERNATIVES

Of course, the above method isn't the only way to make a GIF. In fact, most people opt for quicker, simpler means of turning video into a more shareable format by heading to sites such as Giphy (http://giphy.com) and Gfycat (http://gfycat.com). While there's nothing inherently wrong with either of those, they are a little limiting. In either case, you can only work with videos that are already hosted online, so if you want to use something you shot yourself, you need to upload on to Facebook or YouTube first. Secondly, you're only able to set the start and end points by way of editing. If you're trying to condense 20 seconds or more into a sub-10-second loop, Giphy and Gfycat aren't your friends. There will be occasions when all you need is to trim a YouTube video to size, but we think it's always better to have that bit extra control.

Fake a 360-Degree Photo for Facebook

YOU'LL NEED THIS

PHOTOSHOP
Subscribe at www.adobe.com.

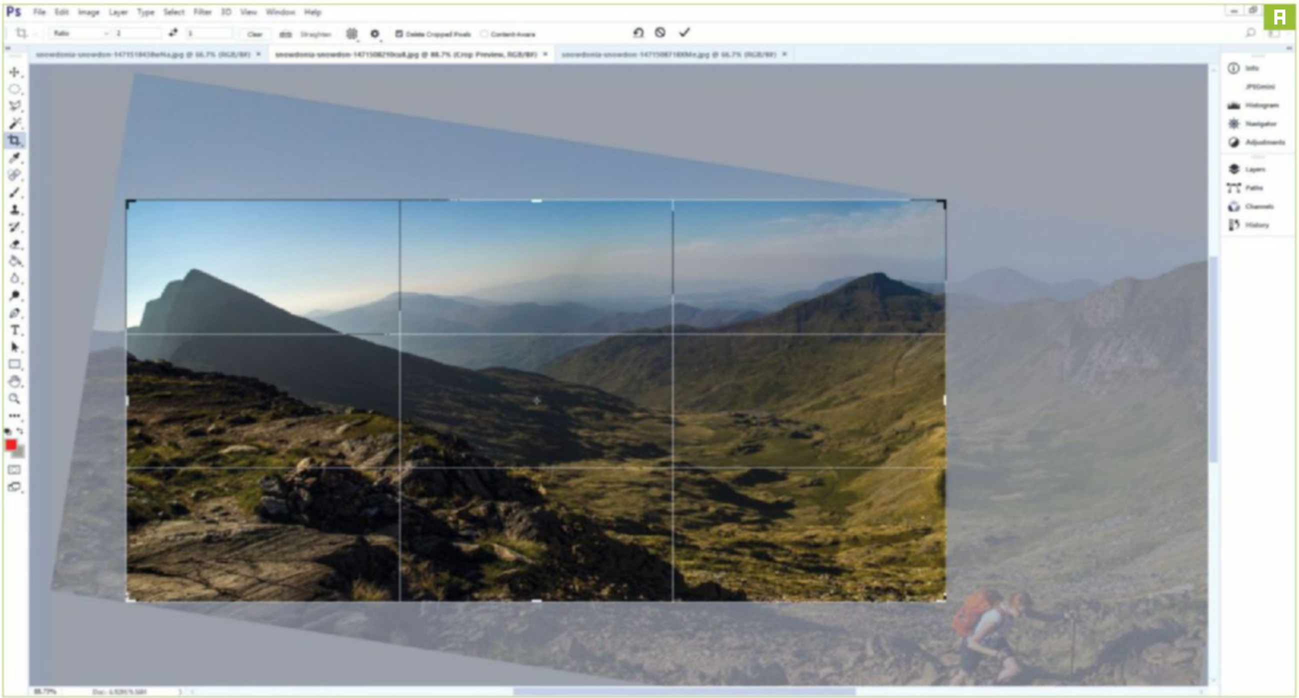
SOME PHOTOS
See step one for requirements.

A FACEBOOK ACCOUNT
Sign up at www.facebook.com.

THOSE 360-DEGREE PHOTOS ON FACEBOOK ARE MAGIC, aren't they? You spin around, and the input from accelerometers in your cell phone is used to scroll the image, giving the impression of peering through a window into another place entirely.

They're usually taken with the kind of camera that would set you back a couple hundred bucks—and you're looking at thousands to get pro-quality gear. Then there's all sorts of rules to follow if you want to avoid catching yourself in the image, and the vagaries of the stitching software, that can make objects disappear around the stitch lines and generally soften the image—which can be a low-res one stretched round to a 360-degree shape. It's far easier and less expensive to fake it.

One day, phones will have these cameras built in, and the software will have improved so it needs no manual input to create a natural-looking video. Until then, there's Photoshop. –IAN EVENDEN


A
Ps File Edit Image Layer Type Select Filter 3D View Window Help
Ratio
2
1
Clear
Straighten
Delete Cropped Pixels
Content-Aware

1 THE PRELIMINARIES

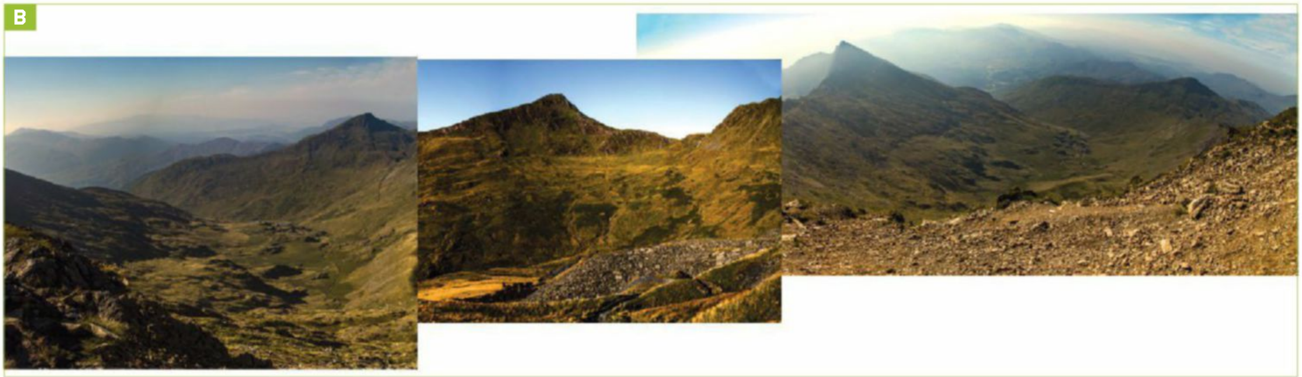
There's a couple things to know about the way Facebook recognizes a 360-degree image before we start. Your file needs to be in a 2:1 aspect ratio, with maximum pixel dimensions of 6000x3000. Then, to make sure it's recognized properly, the metadata needs to contain the "ProjectionType=equirectangular" tag (alternatively, you could use a template with the correct data already in place—there's one here: http://bit.ly/2r4pCRt). More on this later, but for now, choose your source images with care, knowing that you're going to have to crop them to a narrower rectangle than even the 16:9 output by most cell phones. We're using several images to get the required width, which is going to mean blending them together by hand.

2 CROP TO SIZE

You can use the "Crop" tool [Image A] to make sure you stay within the prescribed aspect ratio. With the tool selected, choose "Ratio" from the drop-down menu at the top-right, and input a 2 and a 1 in the appropriate fields. If you're going to stitch multiple images together, you can create a huge canvas, carry out the image merge, then crop the composition to the correct ratio afterward.

3 ALIGN YOUR IMAGES

Open your source images, and align some areas of them by eye [Image B]. We're using three photos of mountains, and can line up some of the peaks quite nicely. There's a bit of an issue at the front, though, because we're left with a chunk of white space where one photo has had to be raised to get the alignment right. Don't forget that your image will wrap around, so the ends meet—this needs to be aligned, too. Cut a rectangle out with the "Rectangular Marquee" tool, and move it to the other end if it helps you to visualize the alignment, or run a horizontal guide across the image, so the horizon never gets out of control.



4 START BLENDING

Once aligned, you need to blend the images together. If you're lucky, and your photos were taken from the same spot, Photoshop's automatic panorama system might do the job—go to "File → Automate → Photomerge." If your pictures weren't taken with the intention of making a panorama, chances are it won't work [**Image C**]. So, selecting the top-most layer in the "Layers" palette, use the "Eraser" tool to remove parts of the scene to reveal the image below, blending the two by hand, leaving no visible join. You might need to use "Levels" or "Hue/Saturation" on one or more layers to get the colors to match. We did, and we dropped in a new sky by running a path across the top of the ridge with the "Pen" tool, clearing out any bits of rock that didn't align properly, continuing the path up the sides and around the top of the image to envelop the sky. We then loaded the path as a selection, and cleared the sky by clicking on each layer in turn, and using "Delete" to remove the selected area. The new sky image was placed on a new layer behind the others, and stretched to fit using "Free Transform."

5 FILL IN THE BLANKS

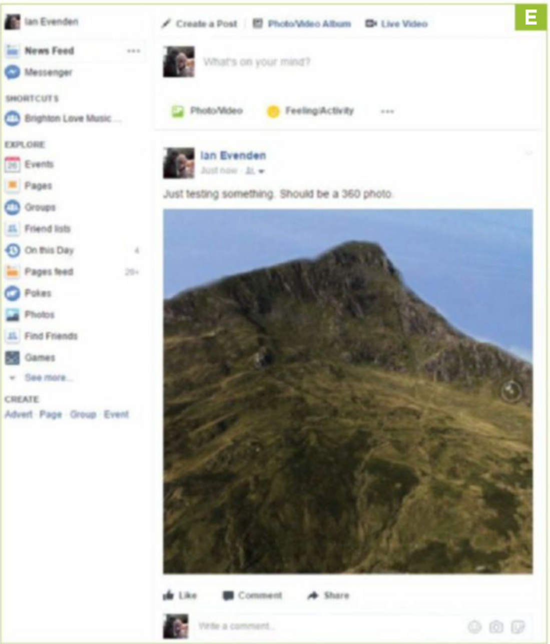
The blank areas at the front are filled in using the "Rectangular Marquee" tool to duplicate (using the "Move" tool and Alt) a large area of scree, and flip it vertically. This blended in nicely, with a bit of "Rubber Stamp" and "Healing Brush" to prevent repetitive features, which always look fake. Once we were happy, out comes the "Crop" tool to fix the 2:1 aspect ratio.

6 ADD EXIF DATA

Save your file as a JPEG. To add EXIF data, you can use ExifTool by Phil Harvey (www.sno.phy.queensu.ca/~phil/exiftool). It's a command-line tool, so follow the instructions on the website, and open a "Command Prompt (Admin)" by right-clicking the "Start" button. The line you want to input is "exiftool -ProjectionType="equirectangular" photo.jpg" where "photo.jpg" is the full path of your file [**Image D**]. You get a new file, the unmodified original, and an updated version of your image.

7 POST ON FACEBOOK

Upload this updated file to Facebook using the desktop browser interface. It should recognize your image as a 360-degree photo—if it doesn't, try running ExifTool again. Hit "Post," and your image is available for all your friends to see and scroll around [**Image E**]. ⏻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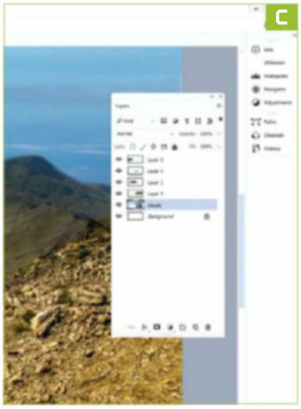
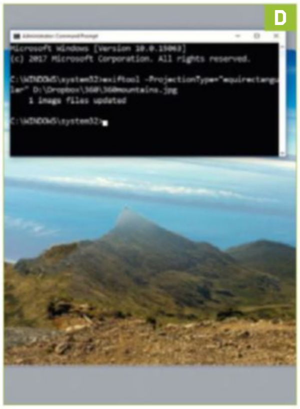
News Feed
Messenger
SHORTCUTS
Brighton Love Music ...
EXPLORE
Events
Pages
Groups
Friend lists
On this Day
Pages feed
Pokes
Photos
Find Friends
Games
See more...
CREATE
Advert · Page · Group · Event
Create a Post
Photo/Video Album
Live Video
What's on your mind?
Photo/Video
Feeling/Activity
Ian Evenden
Just now
Like
Comment
Share
Write a comment...

Just testing something. Should be a 360 photo.




D
Administrator: Command Prompt

```
Microsoft Windows [Version 10.0.15063]
(c) 2017 Microsoft Corporation. All rights reserved.

C:\WINDOWS\system32>exiftool -ProjectionType="equirectangu
lar" D:\Dropbox\360\360mountains.jpg
    1 image files updated

C:\WINDOWS\system32>
```

EXIF DATA

The EXIF is text embedded into your image file that can give a lot of detail about it. Cameras insert their make, model, and lens information, as well as the time and date of capture, shooting settings, and GPS co-ordinates into the EXIF, and many apps can read and add to this. It's useful for asserting your copyright, embedding your name into the image file, and many photographers use it to caption their images, or add usage instructions, knowing picture editors will look at the EXIF for details about the scene, and the names of anyone in the picture if the photographer asked them. To find it in Photoshop, look at "File → File Info."

BUILD IT

ZAK STOREY, REVIEWS EDITOR

A New Office Workhorse

We decided to reuse some old hardware to breathe life into a new office desktop

LENGTH OF TIME: **2-3 HOURS**

LEVEL OF DIFFICULTY: **MEDIUM**

THE CONCEPT

REST IN PIECES, my merry little workstation, you served this editor well. Over the last 18 months, your tiny ITX form factor made you an office dream, and contributed to vast quantities of words in the battle against magazine deadlines.

Featuring a Core i7-4790K, 16GB of DDR3, and a GTX 970, this SSD-powered, liquid-cooled machine lay within Fractal Design's Define Nano S, looking lively each morning, and serving the magazine with vigor until its dying day. Alas, thanks to one too many ghosts in the system, one too many BIOS glitches, we had to put "Old Yeller" down for good.

When it comes to review hardware, we usually consider the parts to be loans. If a manufacturer requests a part back, we return it as soon as possible. Some manufacturers leave us permanent samples (CPUs and reference GPUs, in particular), so we can work closely with their AIB partners and compare against future launches; other parts we request to hold on to (motherboards for dedicated test benches); and some companies just forget to collect their gear (power supplies, SSDs, memory, and so on). Cases are usually a permanent fixture, because shipping them back and forth to tech journalists across the US is a nightmare.

So, for this build, the rules are as follows: Key components (motherboards, processors, power supplies) can't be less than a year old, cases have to be reviewed, and the GPU can be as new as you like, as it's easy to swap out.

GEFORCE GTX

IT'S ALL ABOUT BALANCE

THE PHANTEKS ECLIPSE P400S, at just $80, has a gloss white finish, solid metal panels, tempered glass, magnetic dust filters, hidden SSD mounts, a PSU cover, a fan controller, RGB lighting, noise dampening, and a magnetic 12-inch RGB LED strip. Exceptional spec for the price, and it looks outstanding.

From the cupboard, we dragged out our aging Core i7-5820K, for six cores and 12 threads of pure perfection, plus 32GB of quad-channel Crucial Ballistix Elite DDR4, and baked all of it into the Asus X99 TUF Sabertooth we've had kicking about since 2015.

We reused the Crucial MX200 960GB SSD as the data drive here, but as its now end of life we'd recommend the 1.1TB MX300 instead. For the OS, we used PNY's CS2030 240GB M.2 PCIe SSD.

In 2016, Be Quiet! sent us a sample of its upcoming 240mm AIO Silent Loop. Unfortunately, it never made it past Asetek's trademarking campaign against the closed-loop liquid-cooled industry in the US, and it's yet to make it on sale. You can buy it, but it's extortionately priced, and imported from Europe.

For GPU, we went for a reference GTX 1080 Ti. We're starting to receive a lot more aftermarket 1080 Tis, so popping this isn't the end of the world. And if we need it for something else, swapping it out for another isn't going to be an issue. It can easily handle the two 27-inch 144Hz screens connected to the build, with more than enough grunt for lunchbreak gaming in ultra spec glory.

INGREDIENTS

PART		STREET PRICE
Case	Phanteks Eclipse P400S	**$80**
Motherboard	Asus X99 TUF Sabertooth	**$303**
CPU	Intel Core i7-5820K	**$375**
Memory	32GB (4x 8GB) Crucial Ballistix Elite DDR4 @ 2,666	**$300**
GPU	EVGA GeForce GTX 1080 Ti	**$700**
PSU	Corsair AX1200i	**$350**
Storage 1	240GB PNY CS2030 M.2 PCIe SSD	**$180**
Storage 2	1.1TB Crucial MX300 2.5-inch SSD	**$273**
Cooling	Be Quiet! Silent Loop 240 + 5x Be Quiet! Silent Wings 3 High Speed 120mm	**$268**
OS	Windows 10 Home	**$100**
Total		**$2,929**

1 DUST FILTERS?

WE KNOW WHAT you're thinking: Where are them filters at? We haven't removed them for the sake of snapping a clearer picture here—they're actually baked into the front panel in a very intuitive way. Because of the design of that panel, the only air intakes are situated at the top and the bottom of the trapezoid-shaped structure. What Phanteks has done is create two tiny, removable fan filters, which slot across both of these entrances. This saves on cost for Phanteks, and still acts as an effective dust filter for the end user.

2 UNRELEASED AIO

IT'S A SHAME that the Be Quiet! 240mm AIO Silent Loop never made it to market in the US, because it's truly a thing of beauty. The brushed aluminum block is exceptional, with a single braided cable for the pump, and that's it. No LEDs, no excess mess, and a fantastically simple mounting solution. Even the coil-wrapped tubing grows on you over time. It's right at home with our 32GB of Crucial Ballistix Elite and the X99 TUF Sabertooth motherboard. Our white AX1200i cables, on the other hand? Well, they're starting to look a little grubby, so it's probably best that they're relegated to this system.

be quiet!
BALLISTIX
THE ULTIMATE FORCE

3 MORE COOLING OPTIONS

WHAT YOU'RE LOOKING AT here are the two Silent Wings fans included with the Silent Loop 240mm AIO. However, they're actually optimized more for airflow than static pressure. So, instead of mounting them on the cooler, we popped them on top to, act as exhausts—and utilized a whole plethora of Silent Wings 3s for the AIO instead. One of the more impressive inclusions with the Eclipse P400S is the multiple options for cooling. By default, the case comes with two magnetic white plastic vent covers. You can pull these off for unfettered airflow and more fan mounts, and leave it open, or attach the two 140mm magnetic dust filters that Phanteks has included with the case.

4 REAR I/O GALORE

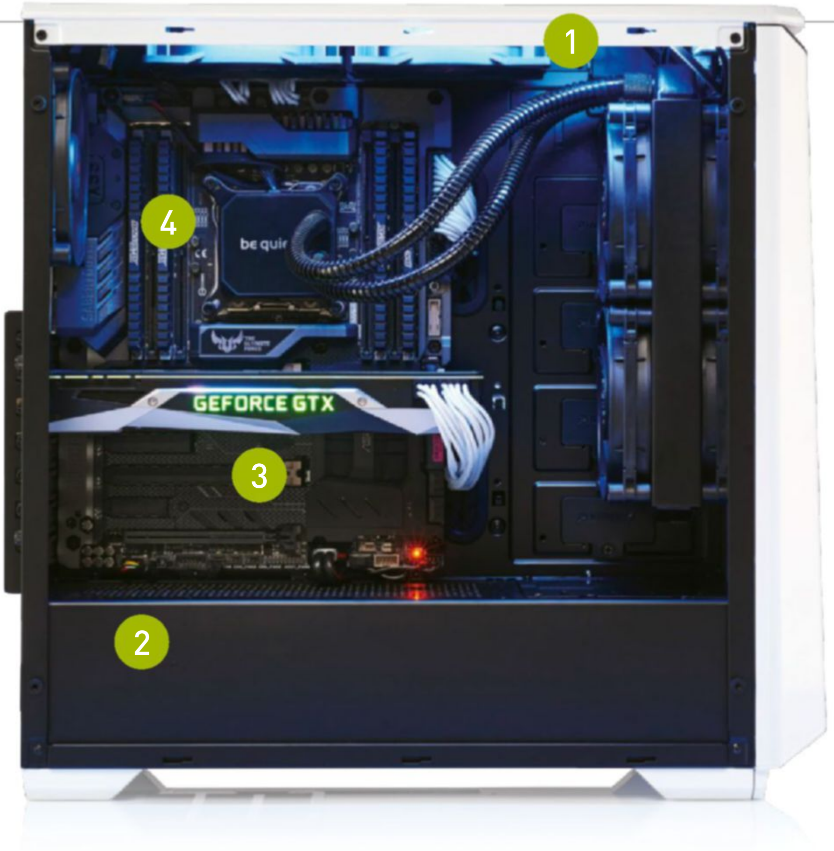
A BIG CONSIDERATION when it came to choosing the X99 TUF Sabertooth was I/O. To give you an idea of the setup, we have Ethernet going in for Internet, one local WD My Cloud NAS network, a Logitech C930e webcam, a Razer Chroma keyboard, Mionix Castor mouse, external hard drive, SteelSeries Siberia 840 headset wireless hub, a Samsung Wireless Qi Charger, and two DisplayPort screen outputs as well. On top of that, from time to time, USB sticks, additional external hard drives, and peripherals that we're testing are all plugged into the hard-working machine. The Sabertooth and GTX 1080 Ti combine to provide more than enough I/O for that profusion of gear.

5 CHILLINGLY SLEEK

AND HERE ARE those two magnetic dust filters we spoke about earlier, sitting proud and true. You can mount two 140mm fans here, but because OCD is a massive thing for this particular writer, keeping the fan branding consistent is key. We also couldn't mount the AIO in the roof, because the X99 TUF Sabertooth is a fairly chunky piece of gear. And with the CPU power in the way, it's impossible to mount the AIO there with this particular combination of parts. To compensate, we decided to ramp up the cooling with push/pull on the AIO instead.

6 NOISE DAMPENING

HERE'S THE FRONT PANEL detached from the chassis. You can spot the two tiny removable fan filters located at the top and the bottom, providing both easy maintenance and cleaning, and sufficient filtration. You may also notice the sound dampening material lining the front panel. It can also be found on the rear side panel, and the two plastic roof covers—if you decide to keep them in, of course. The tempered glass acts as suitable noise dampening as well, helping to keep the humming of whatever fans you install to a minimum.



1 We stuck the LED strip along the top of the case. It lights up the build a treat, and is controlled via a button on the front of the case.

2 The PSU cover may be very basic, but we're not sure we'd invest in a case without one.

3 The armor hiding the PCIe M.2 SSD has always been a favorite feature of ours, and one of the neater details of the X99 TUF.

4 32GB of DDR4 feels like the standard for any HEDT build today. Especially if you're looking to do a bit of everything.

READY FOR WORK

THIS SYSTEM was built to do anything and everything. Whether that's casual gaming, testing benchmarks, web browsing, media editing, general office stuff, you name it, it can do it proficiently and efficiently. Arguably, the old system would have done this as well—but as competently? Not likely. In today's era of Ryzen multicore processors and PCIe SSDs, however, it would have made more sense to go out and buy a Ryzen 7 1700 and something of equal caliber for the motherboard, if you were building this yourself. But that's not something we have the luxury of doing in the office.

The build itself was relatively unchallenging (outside of the socket needing a bit of love). Working inside the P400S was exceptionally enjoyable. We can't emphasize enough how impressive this case is as a value offering. You could pay $120 for this thing, and still feel as though you're getting a good deal. Mounting any AIO radiator, fans first, is always challenging, so that's something to look out for, especially if you're considering a push/pull orientation, because you have to thread the long bolts through the fans, then into the threads of the radiator, without necessarily being able to see them. It can take a few attempts to get it right, but that's about the only awkward part of the entire build.

And then there's the performance. It's definitely an upgrade over what we had prior to this, and it performs great, outside of the ecosystem. Compare it against Ryzen and any modern offerings, however, and the chinks in the armor start emerging. The PCIe SSD, although providing fantastic reads, is a little lackluster on the writes, and the CPU rendering performance, although impressive, lacks substance in contrast to its Ryzen counterpart. Admittedly, video rendering isn't something we do on a day-to-day basis, but when we do, we need it done ASAP.

Graphics is where it's at, though. And the GTX 1080 Ti is the king of the hill right now. However, it's in rather an odd position as a card, because it seems like good value, but only thanks to Nvidia artificially creating that market, because AMD has yet to provide any substantial form of competition at the high end. It's cheaper than a Titan Xp by an incredible margin, while touting very similar performance, and it's leaps and bounds more powerful than its GTX 1080 predecessor, by a factor of almost 30 to 40 percent in most cases—for only $200 more. You feel like you're getting a good deal, but in reality, if AMD were actually competitive right now, seeing this card at $500–600 wouldn't seem like such a huge shock. In this build, it dominates our testing suite at 1080p, as is to be expected. And it makes gaming at 1440p during lunchbreaks particularly enjoyable.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi-Thread	987	1,213 (23%)
Cinebench R15 Single-Thread	196	164 (-16%)
TechARP's X264 HD 5.0.1 (fps)	21.93	26.93 (23%)
CrystalDisk QD32 Sequential Read (MB/s)	1,895	2,150 (13%)
CrystalDisk QD32 Sequential Write (MB/s)	949	400 (-58%)
Rise of the Tomb Raider (fps)	76	93 (22%)
Far Cry Primal (fps)	72	113 (57%)
The Division (fps)	42	132 (214%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point PC uses a Core i7-6700K CPU @ 4.6GHz, an AMD R9 Fury X, and 32GB of RAM. All games are tested at 1080p on max settings, with HD texture packages installed.

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REVIEWS

TESTED. REVIEWED. VERDICTIZED.

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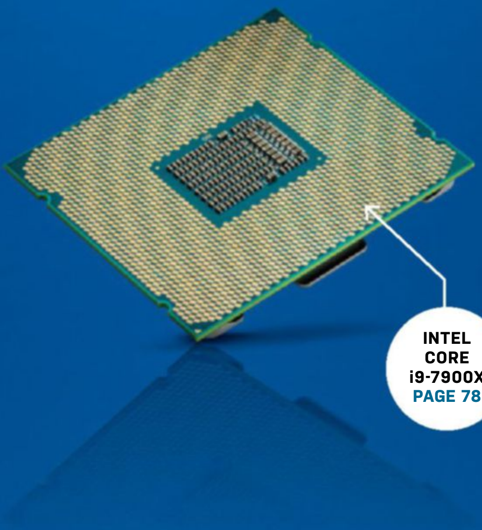


INTEL CORE i9-7900X PAGE 78

Intel Core i9-7900X

Ten cores: Just the beginning...

SOMETHING WEIRD is happening at Intel. Recent years have seen small, incremental upgrades to its top-drawer enthusiast chips. A speed bump here, a couple extra cores there. And that was if you were lucky. Out of nowhere, however, Intel announced a whole box full of new CPUs, a new LGA2066 socket to stick 'em in, and a new X299 chipset to underpin the whole shebang.

The new chips aren't the usual minor massaging of specs, either. In one fell swoop, Intel has gone from a maximum of 10 cores for desktop PCs to 18 cores, with additional 'tweener options filling the newly opened chasm between the old and new realities of Intel's high end.

That's all remarkable enough. Where the real weirdness comes in is that Intel has announced all those new CPUs, but hasn't been able to provide full specifications. For the 14- to 18-core models, we know the model names and core counts, but that's pretty much it. We don't know clock speeds or TDPs. The reason, almost certainly, is that those chips are a hasty reaction to the announcement from AMD, Intel's only rival in the performance PC processor market, involving a shocking new 16-core CPU known as Threadripper. From nowhere, Intel is faced with some real competition. Its reaction feels like a loss of composure.

Intel also announced a pair of very odd quad-core models, which also slot into this new platform, but are actually based on the existing Kaby Lake mainstream quad-core CPU die, complete with integrated graphics. Except the integrated graphics will be disabled in this application. Like we said, weirdness abounds.

But what of this Core i9-7900X CPU? It's a 10-core chip based on the Skylake-X microarchitecture—likely the CPU Intel had intended to roll out as its top offering for the new X299 platform. That's why it's ready for launch now, and everything above arrives later this year, at the earliest.

Across all 10 cores, the base clock and Turbo speeds are 3.3GHz and 4.3GHz respectively. However, the revised favored core mode, also known as TurboMax, can crank up the clocks on the two highest performing cores to 4.5GHz. The idea is to ensure that these multicore models deliver the best of both worlds—lots of cores and threads for multithreaded software, and high clocks when performance depends on one or two really intensive threads. The equivalent clock speeds for the old 10-core Core i7-6950X are 3GHz, 3.5GHz, and 4GHz.

In terms of features, one headline-grabber is the addition of AVX-512 support. That was previously the preserve of Intel's big-ticket Xeon processors, to which all these new Core chips are, of course, closely related. AVX-512 is part of a long line of floating-point extensions to the x86 instruction set, which date right back to the likes of MMX and SSE. In reality, few, if any, desktop applications currently support AVX-512. But the feature is now available, and that will change over time.

More important, however, are revisions to the cache memory hierarchy. The obvious change amounts to more L2 cache and less L3 cache per core. However, the details involve a shift from inclusive to non-inclusive cache, which in turns means a shake-up in terms of policy, latency, and efficiency. In short, it will take time for the full implications of the changes to the cache to shake out, but very likely some apps will benefit significantly more than others. It's a fairly radical change.

Unpicking all that will take time. What we can initially say is that the big jump in the all-cores Turbo clock speed certainly contributes to a healthy uptick in performance of around 20 percent in multithreaded apps, such as Cinebench. Factor in the $999 price tag, where the old 6950X was a $1,700 chip, and the new 7900X looks very compelling. It is the fastest PC processor yet, and by some margin. But that's only for now. When AMD's Threadripper arrives, that $999 figure won't look nearly so clever. –**JEREMY LAIRD**

VERDICT

8

Intel Core i9-7900X

⊞ **THREAD RIPPER** The fastest PC processor yet; great combo of cores and clocks; big price cut.

⊟ **JACK THE RIPPER** Will be usurped very shortly; AMD's upcoming 16-core chip will make it look expensive.

$999, www.intel.com

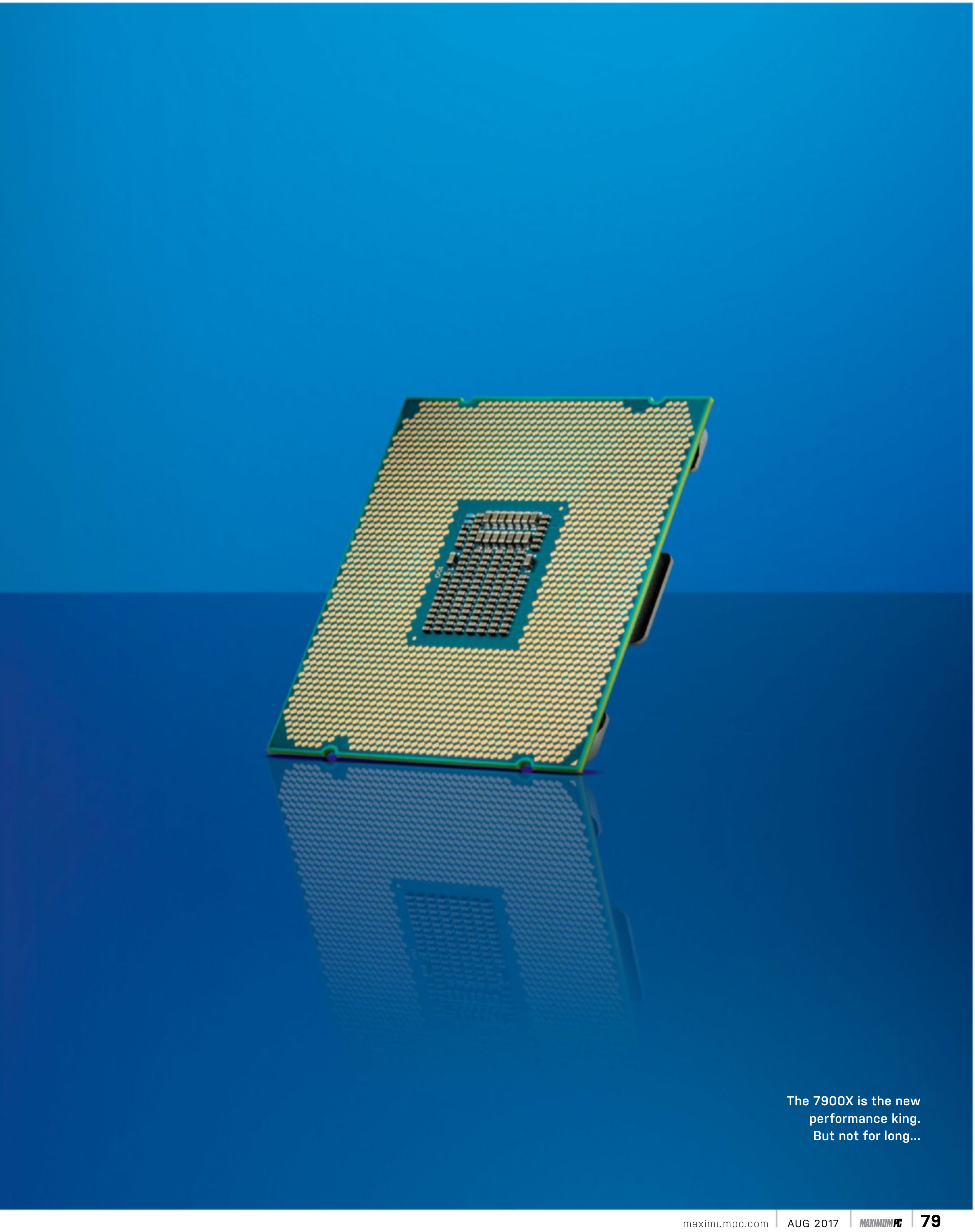
BENCHMARKS

	Intel Core i9-7900X	Intel Core i7-6950X
TechARP's x264 5.0.1 (fps)	**45.1**	30.62
Cinebench R15 Single (Index)	**180**	156
Cinebench R15 Multi (Index)	**2,218**	1,759
Y-Cruncher Pi (Millions of Digits/Sec)	**19.36**	16.57
Power Draw Idle (Watts)	146	**143**
Power Draw Load (Watts)	352	**231**
Total War: Warhammer DX11 (fps)	**144.9**	128.1
Far Cry Primal DX11 (fps)	**107.1**	103.1
Rise of the Tomb Raider DX12 (fps)	**128.5**	126.1
Deus Ex: Mankind Divided DX12 (fps)	**99.7**	97.9

Best scores are in bold. Our test beds consist of X299 Asus Deluxe and Asus RoG Rampage V Edition 10 motherboards, an Nvidia GeForce GTX 1080 Ti, 32GB (4x 8GB) Corsair Dominator Platinum DDR4-2400, and a 250GB Samsung 850 Evo SSD. All games were tested at 1080p on the highest graphical profile.

CPU SPECIFICATIONS

Base Clock	3.4GHz
Turbo Clock	4.3GHz (4.5GHz Max)
Cores	10
Threads	20
Lithography	14nm
Cache	13.75MB (L3)
Memory Support	DDR4 @ 2,666
Memory Channel	4
Max PCIe Lanes	44
TDP	140W



The 7900X is the new performance king. But not for long...

PRIME
X299 SERIES
LGA2066
FOXCONN
ASUS
PRIME X299-DELUXE
CRYSTAL SOUND

We're not quite sure what real benefit X299 offers.

Asus Prime X299-Deluxe

Our first look at Intel's new Skylake X platform

WHAT A TIME to be a tech enthusiast. We haven't seen knee-jerk reactions like this since the early 2000s. Intel appears to be on the back foot, and it knows it. The response to Ryzen, though? Well, it leaves a lot to be desired. This is the first time we've had a good look at the X299 chipset in all its glory. The new all-encompassing HEDT platform from Intel is designed to encapsulate both the low-end and high-end desktop parts—everything from four-core, four-thread processors, right up to 18 cores and 36 threads. This new spec opens up more questions than answers, though, and looks to be, at first glance at least, far less appealing than Intel would want you to believe.

Right then, compliment sandwich time. Positives first. Well, Intel has finally upgraded its direct media interface (connecting the processor to the chipset) to DMI 3.0, essentially swapping out the 4x PCIe 2.0 lanes to 3.0 lanes, doubling bandwidth in the process. No doubt this is to cope with the extra bandwidth necessary to cater for the substantial upgrade to the integrated PCIe lanes on the chipset itself, because we've seen a leap up from eight PCIe 2.0 lanes to 24 PCIe 3.0 lanes. This is seemingly a leaf taken from the mainstream Z270 platform, as its expansive support for multi-GPU and PCIe SSD solutions is one of the few things that differentiates it from the competition. And, on top of that, well, there's a few extra USB ports here, too, but that's about it.

Now the bad. Looking at it entirely from a chipset versus chipset point, there's still no support for USB 3.1 or 10Gb/s Ethernet. And from a platform perspective, we're still stuck on quad-channel memory (on the processors that support it). The latter being the biggest point of contention. Our main issue with X299 all comes down to how many processors this new socket supports. Intel will happily sell you a four-core Core i5 part, with no Hyper-Threading, dual-channel memory, and a measly 16 PCIe 3.0 lanes for no less than $250. Regardless of how high you can overclock these parts, the notion of paying $10 more for a processor that is, in reality, just a migrated Core i5-7600K, sans integrated graphics, is ludicrous. Especially when you can't take full advantage of that new platform you're investing in from the get-go. In fact, the cheapest motherboard we've seen is the Asus TUF X299 Mark 2, coming in at a staggering $260. So that's $510 to start you out in this new HEDT platform, yet without any of the perks associated with it. You could achieve identical performance with an Intel Core i5-7600K and an ASRock Z270M Pro4, for a total of $360.

MAKING NICHE

Back to the good: Arguably, it does provide you with a substantial upgrade path if, say, you're planning to purchase a higher-specced processor later down the line. But really? That's niche. Real niche.

Right. Enough with the jibber jabber. How's the X299-Deluxe looking? Well, it's one of the priciest X299 boards available right now—coming in at a staggering $490, it's not cheap. But, for the money, you get a well-equipped board, featuring three PCIe 3.0 x16 slots, an M.2 heatsink, vertical M.2, U.2 support, six SATA 6Gb/s ports, plus DDR4 support all the way up to 4,000MT/s. On top of that, the RGB lighting is actually fairly classy, and there's a neat little Asus LiveDash OLED display that shows CPU temperature, frequency, fan speed, and UEFI BIOS errors.

It's one pricey piece of PCB, but the arsenal of connectivity littered across its sultry form is enough to keep any PC enthusiast happy. Whether X299 is worth it, though, well that's hard to say right now. As usual with any new Intel process, we're witness to a 10–20 percent increase in performance, and that's about it. As a platform, Skylake X feels lackluster in contrast to its predecessors, and even to Ryzen. We should see some interesting competition once those 12-core and above parts reach the consumer ecosphere, but until that happens, as far as we can tell, there's very little reason to upgrade over the X99 platform.

Couple that lack of excitement with the somewhat vague price drop—seemingly in an attempt to keep pace with Ryzen's ridiculously cheap eight-core offerings—and the overall strategy of Skylake X appears somewhat ill-timed and underwhelming. And with AMD's EPYC-based Threadripper 16-core parts just around the corner, we're starting to wonder whether Intel might have lost the plot on this one. **–ZAK STOREY**

VERDICT
8

Asus Prime X299-Deluxe

⊞ **OPTIMUS** Stunning mobo; well equipped; upgrade to onboard PCIe chipset; nice RGB.

⊟ **OCTOPUS** Pricey and confusing platform; not a huge upgrade over X99.

$490, www.asus.com

CPU SPECIFICATIONS

Chipset/Socket	X299/LGA 2066
Form Factor	ATX
Memory Support	128GB DDR4 @ 3,333MT/s
M.2/U.2 Support	2x M.2 PCIe x4, 1x U.2
SATA Support	6x SATA 6Gb/s
Max PCIe Support	43x PCIe 3.0 x16 (x16x16x8)
Rear I/O	Wireless AC, BIOS reset, 2x Intel Gigabit Ethernet, 4x USB 2.0, 4x USB 3.0, 3x USB 3.1 Type A, 1x USB 3.1 Type C, 5.1 audio, optical out

Asus ROG Strix GL502VS

A truly portable gaming powerhouse

WE'RE BIG FANS of 15-inch laptops. They're large enough to give you the screen real estate needed to play games without squinting, but not so large (looking at you, 17-inchers) that they require a special gaming laptop backpack to lug around all day. They're the form factor that lets a portable gaming machine feel portable.

Asus's ROG Strix GL502VS delivers on portability. Measuring only 1.18 inches (30mm) thick, it's one of the thinner GTX 1070 laptops we've tested, fitting into a new breed of portable pixel-pushers that don't require massive jet engines to cope with the heat output of mobile graphics chips.

Inside, the GL502VS features an Intel Core i7-7700HQ CPU, 16GB DDR4 RAM, and a GTX 1070 GPU. Where it sets itself apart, aside from the form factor, is in its display. Where most gaming laptops offer a 1080p G-Sync IPS screen, they are mostly held back by panels with a 60Hz refresh rate. The GL502VS steps things up with a 1080p "IPS-like" matte panel with a 120Hz refresh rate. Frankly, much of the GTX 1070's pixel-pushing power is wasted on a 60Hz screen, as it's more than capable of maintaining frame rates well above 80–100fps at 1080p. With the GL502VS's 120Hz G-Sync screen, you aren't forced to choose between screen tearing and higher than 60fps.

Speaking of frame rates, the GL502VS easily handled everything we threw at it. It scored an average of 103fps across *Rise of the Tomb Raider's* three-part benchmark, scoring 128fps in the Mountain Pass, 95fps in Syria, and 86fps the Geothermal Valley, all at 1080p max settings. In *Far Cry Primal*, it scored 80fps using the in-game benchmark, and 79fps in *The Division's*. Finally, it scored 13,202 in 3DMark Fire Strike. Those numbers destroy our laptop zero-point, and are on par with or better than our desktop.

COMPACT AND POWERFUL

The GL502VS's chassis is a vast improvement over Asus's larger, more expensive G752VS, the updated version of the company's flagship gaming laptop. The GL502VS has a more understated look that maintains a bit of the ROG brand's angular aesthetic, while toning down some of the more aggressive styling—and in a smaller package. Of course, the G752VS's size mostly comes from its large rear vents, but in our testing, the GL502VS's smaller size didn't limit it thermally in any noticeable way, and it comes in at a much more attractive price point.

For connectivity, the GL502VS has all the usual suspects: three USB 3.0, alongside one USB Type-C, as well as one each of HDMI and Mini DisplayPort for connecting to external monitors. Unfortunately, it's missing Thunderbolt 3 connectivity in the Type-C port, limiting transfers to 10Gb/s instead of Thunderbolt 3's blazing 40Gb/s.

The other main drawback is battery life: With only a 62WHr battery, the power draw of the GTX 1070 means your time untethered from the wall is limited to an hour or two, even when not gaming. That said, the low battery life is more than made up for when considering the GL502VS's price. At $1,699, it's hundreds of dollars cheaper than most GTX 1070 laptops. And while it's not the most portable—especially compared to the ultra-thin Razer Blade or upcoming Nvidia Max-Q laptops—it's small enough for a normal backpack, and light enough to not break your back. Of course, if you insist on more screen real estate, the 17-inch GL702VS is effectively the same laptop in a larger frame. **–BO MOORE**

VERDICT
8

Asus ROG Strix GL502VS

+ ON THE ROAD Great performance for the price; 120Hz G-Sync display; not super-bulky.

− HOUSE ARREST Poor battery life; no Thunderbolt 3.

$1,699, www.asus.com

SPECIFICATIONS

Processor	Intel Core i7-7700HQ @ 2.8GHz
Graphics	Nvidia GeForce GTX 1070 8GB
RAM	16GB DDR4-2400
Screen	15.6-inch 1920x1080 matte 120Hz G-Sync
Storage	128GB SSD, 1TB 5,400rpm HDD
Battery	Four-cell Li-ion
Networking	802.11ac wireless LAN
Connectivity	3x USB 3.0, 1x USB 3.1 Type-C, 1x Mini-DP, 1x HDMI, SD/MMC card reader, Bluetooth 4.0, 1x headphone/mic combo jack
Dimensions	15.4 x 10.5 x 1.2 inches
Weight	4.8lb

BENCHMARKS

	ZERO-POINT	
Cinebench R15 (Index)	682	739 (8%)
Tech ARP x264 (fps)	15.17	16.52 (9%)
PCMark 8 Creative (Index)	6,180	7,015 (14%)
CrystalDiskMark 4K Read (MB/s)	44.2	35.38 (-20%)
CrystalDiskMark 4K Write (MB/s)	162.1	109.3 (-32%)
Far Cry Primal (fps)	37	80 (116%)
The Division (fps)	33	79 (139%)
Rise of the Tomb Raider (fps)	42	103 (145%)
3DMark Fire Strike (Index)	6,583	13,202 (101%)
		0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our laptop zero-point is the Asus G752VT-DH72, with an Intel Core i7-6700HQ, 3GB GTX 970M, and 16GB of DDR4-2133. All games were tested at 1080p at the highest graphical profile with antialiasing enabled.

The GL502VS delivers the performance of a larger, more expensive laptop, but without the bulk.

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AMD Ryzen 5 1400

Give it up for AMD's budget Intel-killer

BE CAREFUL what you wish for. One moment, we're begging Intel to stop with the sandbagging; the next, it's slinging a bewildering array of new CPUs into the market, measuring everything from 4 to 18 cores. Strange and exciting times indeed.

But with the fallout from Computex still in the air, it's easy to lose sight of the less spectacular versions of the chip that started it all. We speak of AMD's Ryzen—in particular, the Ryzen 5 1400. Currently, it's the lowliest Ryzen of all. But considered in context, it's also the most relevant.

That context is delivering four proper CPU cores and support for eight software threads at a significantly lower price than Intel. The Ryzen 5 1400 clocks in at $170. The cheapest quad-core Intel chip, the Core i5-7400, doesn't look too distant at $185, but it only packs four threads. If you want eight threads from Intel, it's a huge leap up to the $305 Core i7-7700.

Of course, one can debate the value of the simultaneous multithreading technology that allows a CPU core process more than one thread in parallel, but let's not get ahead of ourselves. First, we'll cover some speeds and feeds. Along with those four cores and eight threads, the Ryzen 5 1400 weighs in with a 3.2GHz base clock and a 3.4 maximum Turbo speed. Like its quad-core sibling, it's rated at 65W, and slots into AMD's new AM4 mainstream CPU socket.

It also packs a total of 384KB of L1 cache and 2MB of L2 cache. Again, that's a dead heat with the 1500X. Where things diverge and the comparison becomes rather intriguing involves L3 cache. The 1400 sports just 8MB to the 1500X's 16MB.

That's intriguing, not simply because the 1500X has double the cache, and more cache normally means more performance. It's intriguing because of what it may indicate about the internal structure of the two chips. After all, the Ryzen CPU die is composed of two quad-core complexes, each with 8MB of L3 cache. So you might think the L3 cache count indicates the 1500X operates in a 2+2 configuration with both complexes enabled, but each with just two cores switched on, while the 1400 runs a single-core complex, with all four cores firing away.

For now, it appears that isn't the case. The 1400 runs the same basic 2+2 configuration, just with some of the L3 cache fused off in each complex. However, AMD isn't being hugely forthcoming, so it wouldn't surprise us if it turned out that it was taking both approaches in order to use as many dies as possible.

Ultimately, of course, all that matters is performance, and here the news is mostly very good. The 1400 delivers the kind of numbers you'd expect on the whole, based on core and thread count, and clock speed.

This means that in the most scalable workloads, such as Cinebench, it has the edge over much more expensive quad-core, quad-thread chips, such as the Core i5-7600K, but falls a little short when it comes to software that leans a little more heavily on individual core performance. Like every Ryzen CPU thus far, the 1400 is also fully unlocked, and comfortably achieves 4GHz with the most rudimentary of tweaks, at which speed it's overtaken the 1500X model running at stock clocks, closed some of the single-thread gap to the Core i5, and positively obliterated the latter for outright multithreading throughput.

All of which makes the 1400 a pretty compelling package at its specific price. If there is a problem, it's that the lower down the Ryzen range you go, the more tightly things are packed. Moreover, given you're going to need a new motherboard, and probably some memory, too, an extra $45 for the cheapest six-core Ryzen looks like an awfully good deal. **–JEREMY LAIRD**

VERDICT
8

AMD Ryzen 5 1400

⊞ **CLOCKER** Lots of cores and threads for the money; decent overclocking potential.

⊟ **SHOCKER** Single-thread performance just OK; six cores not much more expensive.

$170, www.amd.com

BENCHMARKS

	Ryzen 5 1400	Ryzen 5 1500X	Intel Core i5-7600K
X265 Benchmark (fps)	13.61	15.85	**15.86**
Cinebench R15 Single/Multi (Index)	131/693	154/**807**	**179**/663
Fryrender Benchmark (m:s)	6:20	**5:29**	5:46
Power Draw Idle/Load (W)	55/**93**	**42**/101	44/103
Total War: Attila (fps)	33	36	**40**
Far Cry Primal (fps)	71	75	**77**
Rise of the Tomb Raider (fps)	**43**	**43**	**43**
Deus Ex: Mankind Divided (fps)	**13**	**13**	**13**

Best scores are in bold. Our test bed consists of an Asus Crosshair VI Hero, 16GB of Corsair Vengeance LPX DDR4, and a GeForce GTX 1080. Games are tested at 1440p on the highest graphical profile, with MSAA enabled.

SPECIFICATIONS

Base/Turbo Clock	3.2GHz/3.4GHz
Cores/Threads	4/8
Lithography	14nm
Cache	8MB L3
Memory Support	DDR4
Memory Channels	2
Max PCIe Lanes	20
TDP	65W

AOC AGON AG271UG

AOC's latest premium panel comes at a price

WE LIVE IN AN AGE when tablet computers with high-DPI IPS screens are handed out in boxes of Corn Flakes (other corn-based cereals are available). Well, almost. Similarly, you're nobody in the smartphone game without a decent high-DPI IPS panel at the very least. To be really competitive, you're talking OLED technology.

Yet the one device that could both most benefit from and make the best use of such displays lags miles off the pace, wheezing along as other devices dip over the horizon. Yes, we speak of the PC. That's not to say the PC monitor market has been stagnant. Far from it, what with the arrival of adaptive sync, HDR, and super-wide aspect ratios. Resolutions and panel sizes are up, too.

But true high-DPI? Not so much. At least, not at a price most of us can afford. So, it's hardly surprising to find that AOC's latest premium panel, the AGON AG271UG, clocks in at $799. It's a 27-inch model, with IPS tech, and a healthy 4K pixel grid. That makes for a relatively high 168 pixels per inch for a PC monitor. By the standards of phones and tablets, which generally don't get out of bed for less than 250 ppi, it's still pitiful. Likewise, it's hard to understand why this panel costs more than twice the price of a TN 4K monitor of the same size.

Remember also that AOC trades on value. A similar monitor from Asus or Acer would be even more expensive. If it sounds like we're harshing on AOC, far from it. As this type of panel goes, the AG271UG has a lot going for it. It sports lovely, vibrant-yet-natural colors. It delivers well in our test images, too, rendering white and black scales with little visible compression. Super-smooth gradient rendering is on the menu, too. Pixel response is subjectively nice and zippy, to boot, especially for an IPS panel. Even better, all this is achieved with none of that nasty inverse ghosting stuff that's a consequence of aggressive pixel overdrive settings.

Black levels and contrast are good, though not quite a match for the best VA panels. There's little evidence of IPS glow, either, which is welcome. It must also be said that by the standards of PC monitors, the 3840x2160 pixel resolution makes for very sharp image quality and nice font rendering. What you don't get is that super-smoothness that comes with a DPI so high that individual pixels virtually disappear.

You also don't get a truly high-quality stand and enclosure. Superficially, it checks all the right boxes: There's full adjustability, including height, swivel, rotate, and tilt, the bezel is thin, and the stand is made of metal. But the design is dated, and the whole ensemble is awkward to assemble. At this relatively high price, you'd expect a slick clip-in arrangement for attaching the stand to the chassis, not a quartet of cheapo screws. The external, rather than integrated, power supply is worth a demerit or two, as well.

Of course, high-DPI technology implemented on the PC remains a mixed bag, due to the way both Windows and the web handles it. Driving really high resolutions in games is problematic, as well. Likewise, the 4K resolution more or less dictates the AG271UG's 60Hz refresh. 4K 120Hz panels are coming, but they will be even more expensive. So, simply throwing more pixels at a screen like this isn't a cure-all.

But when you can buy a 40-inch 4K TV, capable of 60Hz refresh, for half the price of this, never mind all those high-DPI portable devices for pennies, the value proposition seems marginal. It's a nice screen, this AOC, but like pretty much all of its direct competition, it feels overpriced for what you're getting. –**JEREMY LAIRD**

VERDICT

8

AOC AGON AG271UG

⊞ **SPECIAL K** Lovely 4K IPS panel; 27-inch proportions make for pin-sharp pixels.

⊟ **CAPTAIN CRUNCH** High, going on harsh, pricing; limited to 60Hz; dated styling.

$799, http://us.aoc.com

SPECIFICATIONS

Panel Size	27 inches
Native Resolution	3840x2160
Pixel Density	168 ppi
Panel Type	IPS
Maximum Refresh	60Hz
Response	4ms
Contrast	20m:1 (dynamic)
Display Inputs	DisplayPort 1.2, HDMI 1.4
Connectivity	4x USB 3.0
VESA Mount	100 x 100mm
Warranty	Three years

AG271UG
AGON

Underwhelming styling
and overpriced.

SteelSeries QcK Prism

At last: Just what your desk doesn't need

THE CONCEPT of a fancy light-up mouse pad seems a bit absurd. Sure, maybe you have 60 bucks in your wallet that's possessed by some sort of evil spirit, and which you must dispose of immediately lest you spend the rest of your life dealing with a terrible curse—that's fine, you get a pass, may your demons be sufficiently exorcized. Anybody else in the market for a big-money mouse mat should probably do some cost/benefit analysis on their situation.

But here we are, with SteelSeries's QcK Prism, the third such ultra-pad we've reviewed in these canonical pages, the others coming from Corsair and Razer. This loose triumvirate proves that there is a market for these things. And, though it pains us to admit, mouse pads do still have legitimate use cases. While modern mice are happy to play nice with most materials, glass desks or those with a lightly reflective or incredibly plain coating can scatter optical signals wildly. Dedicated mousing surfaces can improve, or dull, mouse glide, and if you're striving for precision pointing, they can make a difference.

The Prism has a practical purpose, then: It distinguishes itself by offering a slippery hard polymer surface and a smooth micro-textured cloth surface, each on either side of its reversible foam mat. This thin layer sits in a non-slip rubberized well, which grips the pad OK when holding the cloth side, but fell victim, slightly, to our violent mousing tests when the slicker plastic side was face down. Around the rubber is, we assume, the QcK Prism's big selling point, given that SteelSeries will sell you a standard non-Prism QcK pad in exchange for one measly portrait of Alexander Hamilton: that RGB lighting. It's fine. It's bright, it's colorful, and you'll rarely notice the joins between its 12 zones unless you look for them, or configure them to be obvious. It supports GameSense lighting, which can be set up to give visual feedback on particular aspects of particular games. As you'll almost certainly be able to see this light-up rectangle out of the corner of your eye at all times, we could see that being minutely useful.

THE QCK AND THE DEAD

There are some neat design decisions in evidence: The USB cable, for example, has been cleverly located in a low protuberance on the left side of the pad, rather than in a massive lump on the upper edge, as in the case of some competitors, so you won't be clunking your mouse into it at inopportune times or snagging your cable. That's good. The lighting goes all the way around the pad, rather than skipping an edge, which is aesthetically acute. Technically, the QcK Prism is probably a lot better than Corsair and Razer's competitors. So, good for you, SteelSeries: You've made a better RGB mouse pad. But let's be realistic. That's no accolade. That's a begrudging acknowledgment of superiority in a market that only exists because some people will spend money on stuff they don't need.

Tomorrow's fancy mouse pads won't need to stretch to find a purpose. Logitech's forthcoming PowerPlay system, for example, is among a new breed that promises to charge wireless mice, er, wirelessly. We'll almost certainly get angry about that when it's released—because it'll involve a $250 hardware combo, and not having to change a AA battery every few months absolutely doesn't justify that outlay—but that's for another time. Now we're angry about this. If you love it, if you love the idea of it, if your sexy desk needs a sexy RGB black rectangle, if you're so bought-in to SteelSeries's PrismSync lighting that you really must sync every device on your desk? Go on, treat yourself. This is for you. But it's not for us. **–ALEX COX**

VERDICT 6

SteelSeries QcK Prism

+ PRISM Handsome design; choice of mousing surfaces; plenty of color customization options.

− PRISON Pointless extravagance; takes up a USB port.

$60, http://steelseries.com

SPECIFICATIONS

Dimensions	11.5 x 14 x 0.3 inches
Colors	16.8 million, 12 RGB zones
Material	Cloth, plastic, silicon rubber base
Weight	2lb
Warranty	One year

SteelSeries Arctis 7 Wireless Gaming Headset

Grown-up gaming cans with real quality

steelseries

NO RGB LIGHTING? No tribal designs? It's not even named after a Greek god! Is this really a gaming headset? The Arctis 7 definitely does things differently. Central to this $150 wireless headset's design is the "ski goggle" headband, a length of adjustable elastic fabric whose purpose is to keep the full weight of the model from imposing itself on your cranium. It's no gimmick, either. The Arctis 7 remained very comfortable for three-to-four-hour sessions during testing, and beyond that point it was only slight constriction around the ears that emerged. We all have ears of different shapes and sizes, so that's to be expected from any circumaural cup.

A focus on build quality prevails. The earcups are finished with luxurious soft foam padding of the type you'll find in Bose and B&O headphones, and they're affixed to a smart brushed aluminum headband, which sits above the elasticated band. Velour earcups, along with an array of colorful bands, are available separately if you want to go deep into customization.

The other big selling point is lag-free wireless sound. It's been a tough nut to crack in the gaming headset market for years, although the consumer's mistrust of anything wireless is disproportionate to the actual drawbacks. SteelSeries delivered a fantastic wireless package with the "H" headset in 2014, but its $300-plus price tag wasn't to everyone's tastes. Here, we have a $150 headset that pulls a wireless setup together brilliantly. We'll admit to raising our eyebrows at the purported 15-hour battery life on the specs sheet, but our testing revealed it to be bang on. We're dealing with a brand new model out of the box, so it's likely that charge time will lessen over time, but it's a strong starting point.

RANGE ROVER

Its 40-foot range will be enough to keep you entertained while you take a break and head to the refrigerator, and the wireless receiver is small and unobtrusive. Setup is as simple as plugging the receiver in via a USB port, hitting the pair button, and powering up the headset—Win 10 found the drivers right away for us. Get a few cables involved, and you can use the Arctis 7 with your smartphone and consoles, too, which adds some value to that $150 pricing.

All controls are on the headset itself, including a volume scroll wheel, a chat mix wheel, mic mute, and power buttons—the retractable mic sits on the left, and offers crackle-free VOIP. They're sensibly laid out and easy enough to find by touch, although the mic mute button takes a while to get acquainted with, and we found that at very low volume settings, the left side seems louder—it might be our ears.

We're very impressed with the Arctis 7, and its benefits are clear and plentiful. However, when it comes to overall sound quality, it's slightly disappointing. SteelSeries fitted the same 40mm S1 drivers in this model as found in its higher-end headsets, but there's a muddiness here that no amount of preset-tweaking in SteelSeries's own Engine software can remedy. Good sound means a flat frequency response, which can be boosted to taste, but we weren't able to flatten it in the Arctis 7. What's more, the DTS-Headphone X algorithm that often provides a decent soundscape sounds quite narrow. Our regular evening games of *PlayerUnknown's Battlegrounds* got a bit more tense while donning the Arctis 7, as we found it harder to pinpoint footsteps.

This shouldn't put you off buying this headset, unless you're an audiophile or a competitive gamer. Everyone else can square away a bit of extra bass, while enjoying a comfortable and stylish wireless gaming setup. –PHIL IWANIUK

VERDICT
8

SteelSeries Arctis 7

+ **ICE COLD** Great fit; good battery life; solid wireless.

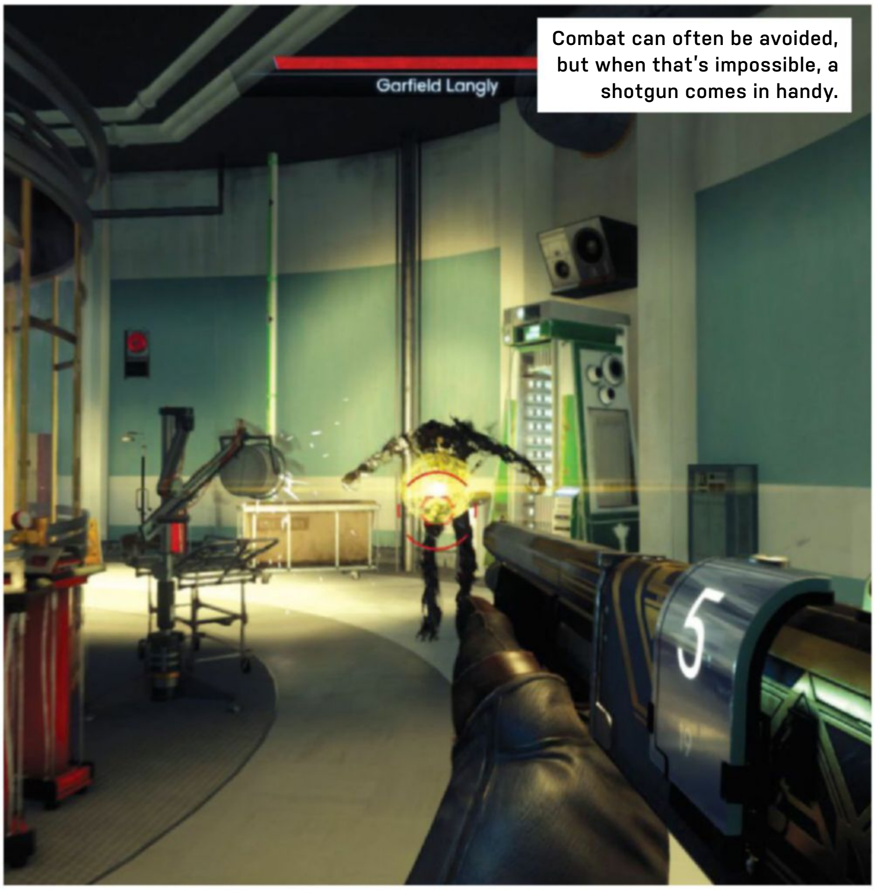
− **LUKEWARM** Poor soundscape.

$150, www.steelseries.com

SPECIFICATIONS

Driver Type	40mm
Impedance	32 ohms
Frequency Response	20–20,000Hz
Microphone Type	Bidirectional
Connectivity	1x wireless receiver
Range	40 feet
Battery Life	15 hours
Weight	9.9oz

Would it be bad to suggest this guy looks like a certain Valve employee?



Combat can often be avoided, but when that's impossible, a shotgun comes in handy.

Space station design certainly involves a lot of corridors.

Prey

You've got to prey, just to make it today

AS YOU PUT ON A SPECIAL SUIT, travel to a test chamber, take part in experiments, and witness an alien outbreak, you might be forgiven for thinking you're playing *Half-Life.* And once you're using a wrench as a weapon, perhaps *Opposing Force.* You're not, but neither are you playing 2006's *Prey,* in which a Cherokee mechanic took down aliens using strange powers. Nor are you playing the canned *Prey 2,* in which the same aliens would have abducted an air marshal, and set him up as a bounty hunter. Which is a shame, as that sounded good.

This has little to do with past uses of the name, other than taking down aliens with strange powers. You're playing an Arkane game, which is not to say that it's *Dishonored In Space*—though that also sounds fun—rather a series of interlocking systems, ability gates, and chunky-faced characters, all disguised as an open-world space station in which to run riot. *BioShock* comes to mind when you enter the art deco lobby of Talos 1, where your brother is making ability-enhancing Neuromods from ground-up aliens, as does *System Shock:* The Looking Glass screens—the original *Prey's* portal system reimagined as 3D video displays—underline this influence.

You'll feel like you're in *Thief,* too, as you pilfer stuff to feed into Recycler machines to create materials. These in turn are fed into Fabricators that, if you have the plans and the materials, can create anything. Unlike *Thief* and *Dishonored,* there's less focus on stealth. Combat is defined by two things: the limited weapon set and the annoying nature of some enemies.

Chief among the annoyances is the Mimic. It's *Half-Life's* headcrab, made from shape-changing smoke. Anything could be a Mimic, and the paranoia is heightened by how many blows from the wrench they take to kill. This isn't helped by a stamina bar that limits how many swings you can take before needing a rest. Gordon Freeman never had this problem. Mimics are at their best when they're running away from you, trying new shapes to shake you off, and plain irritating when they choose to attack.

A beefy shotgun, an energy blaster, and a GLOO gun that can immobilize foes (as well as negate environmental hazards, and provide a climbing surface) take the sting out of bad guys, who get ever more powerful after the Mimics are set loose, gaining skills such as teleportation and ranged attacks as they pursue you.

There's an alternative-history backstory to be pulled out, too, by reading every book and magazine you find, and the ending's as dark as you'd expect. But *Prey's* space station is primarily a playground of mysteries and systems, something to be toyed with that's at its best when you're combining items and abilities, a place built with experimentation in mind. **–IAN EVENDEN**

VERDICT

8

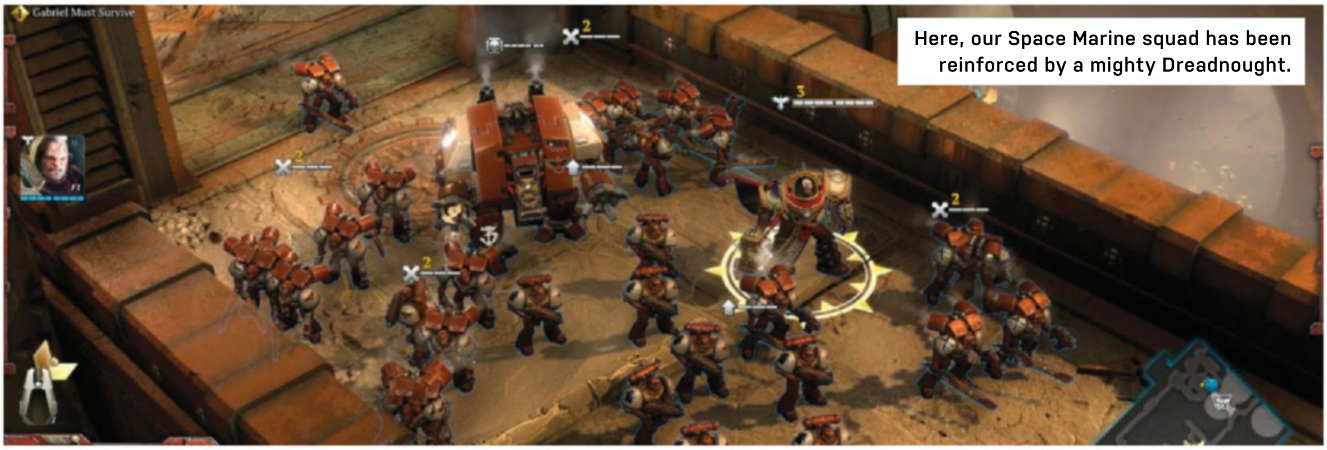
Prey

⊞ PRAISE Ingenious; good-looking; immersive.

⊟ PREYS The most common enemy is the most irritating.

RECOMMENDED SPECS i7-2600K or FX-8350; 16GB RAM; 4GB GTX 970 or R9 290.

$60, http://prey.bethesda.net, ESRB: M



Here, our Space Marine squad has been reinforced by a mighty Dreadnought.

The kick of this cannon can move it across the map.

The Eldar bring a lot of toys, and can even teleport buildings.

Warhammer 40,000: Dawn of War III

Tabletop gaming comes alive, but death's never far off

THE GRIM DARKNESS of the far future, in which there is only war, has turned out to be a fun place to hang out. The Warhammer 40,000 setting has spawned many videogames, but it's *Dawn of War's* sprawling RTS battles, and its sequel's more focused skirmishes, that have done the most for the Emperor's cause, recreating the tabletop game better than any first-person shooter ever could.

The third game attempts to combine the scope of the first two, with three factions (Humans/Space Marines, Orks, and Eldar) duking it out on a planet for a lost Eldar artifact. There's building of bases, management of resources, and scenes where walking metal hulks tear into each other. Single-player rotates you between races, building up a story seen from every side, then twisting it at the end. It serves as a tutorial for the MOBA-influenced multiplayer, introducing the full range of mechanics, and even managing some mouse-throwing moments.

Our Space Marine captain refusing to disengage from combat while we fruitlessly clicked on a health pickup was a low point, the suicidal need to kill Orks exposing the lack of checkpointing and need to quicksave regularly, as we returned to the very beginning of the mission. Couple this with the troops' new-found ability to die really easily, plus the lack of any real cover mechanic, and tooth-grinding can set in.

That last point has been dealt with in a strange way, with areas of cover available for capture, before they pop a shield over your troops. Clearing it out, therefore, becomes an attritional battle of grinding down the shield, or jumping melee units into the middle to gleefully slaughter everyone who thought they were safe. The result is that you get a lot of open battles, rather than sniping at one another, and while line of sight and elevation all play their parts, *40K's* tendency to push troops into close combat means the fighting becomes more closely packed, and you rarely feel like you're taking advantage of the environment.

Adding to this feeling are the elite units. You always have one stomping around, and they've got a huge health bar, a couple of special abilities, and become the backbone of your army. A common objective is for an elite unit to survive, so sustained damage to that unit, along with the occasional lack of clarity about how high the terrain is, can mean the end of your hero.

When it all goes right, however, the blood splatter and rending of metal becomes hugely satisfying. Punching through a mass of Orks with a surgical team of Eldar never gets old, but single-player may struggle to hold your attention if you're not buying it mainly for multiplayer battles. –**IAN EVENDEN**

VERDICT
7

Warhammer 40,000: Dawn of War III

+ ORKY Huge battles with constant turnover of units; quality voice acting; looks good at higher settings.

– DORKY Occasional lack of response from units; massed brawls can become confusing.

RECOMMENDED SPECS 3GHz Core i5; 8GB; GeForce 770, Radeon 7970, or equivalent.

$60, www.dawnofwar.com, ESRB: M

LAB NOTES

TUAN NGUYEN, EDITOR-IN-CHIEF

A Case of Getting What You Pay For

The Mercury S8 is pricey, but worth every penny

AS OFTEN AS I'VE TRIED to stop fiddling with a PC, I just can't—it's in my nature. I've built countless computers, from the very simple to the incredibly complex. And I've come to realize that the chassis you build in affects the entire experience from beginning to end.

In 2015, I built the Dream Machine using a giant CaseLabs chassis that was amazing to work in. Just a few weeks ago, I decided to try my hand again at another CaseLabs chassis that was smaller, but no less astounding.

Coming to customers in a flat-packed box, CaseLabs products are incredibly easy to assemble, and as you put them together, you'll notice nuances that make you think, "Wow, someone is really paying attention to the details." The drive cages, for example, in the Mercury S8 I worked on, mount on rubber rings to the whole frame, and the frame itself snaps together, including the panels. Everything is clean and exact. While some competitors have similar features, CaseLabs, to me, seems consistent in its design and attention to detail.

Every CaseLabs chassis can be optioned and customized to your liking before order, and CaseLabs makes this readily apparent on its website. Some of its products are modular, and can be extended if need be. The Mercury S8 I ordered even comes with integrated radiator mounting, and plenty of room to spare if you want to go all-out on custom loops. Some of the best custom-loop systems use CaseLabs, and it's easy to see why.

Despite all the good things I can list about the Mercury S8, there is a caveat: price. CaseLabs products aren't cheap. In fact, the Mercury S8 will set you back $470, but you get what you pay for. Serious builders only.

ZAK STOREY

Reviews Editor

I'm itching to get ITX back in my life. My current rig is housed in the stunning NZXT S340 Elite, featuring two GTX 1080s in SLI, with a chunky ATX setup, but it's starting to grate a little. I miss my liquid-cooled Manta. That said, going back to ITX provides multiple challenges. Firstly, if I were to upgrade, I would want to swap over to Ryzen. However, there aren't many, if any, suitable ITX boards out there. On top of that, the chassis I would want to use, and potentially liquid-cool, is In Win's newly showcased wooden ITX machine. And finally, I would need to upgrade those graphics cards if I want any hope of enjoying AAA titles on my 3440x1440 Samsung CF791. It's a hard life, eh?

JARRED WALTON

Senior Editor

Testing new hardware can be fun, but it can also be frustrating. Case in point: Intel's new X299 platform. The initial BIOS underperformed, and the second BIOS auto-overclocked the i9-7900X to 4.5GHz on all 10 cores—with no way to disable the feature. Cue BIOS number three. Beta BIOS releases and teething pains on new platforms are expected, and Ryzen 7's launch was even more fraught, with problematic memory support among other things. If you love tinkering with the latest tech, being among the first adds to your geek cred. But if you just want a platform that's stable, and has all the kinks ironed out, wait a few months before climbing aboard. Let others enjoy the maiden voyage.

Editors' Picks:
Digital Discoveries

Bo Moore, technology editor, and Alan Dexter, executive editor, reveal their latest tech highs

LOGITECH G433

I'm not a big fan of the "gamer" aesthetic. RGB lighting and aggressive styling on keyboards, monitors, and cases do very little for me, but at least they're only seen in the home. Things get tougher in the headphones space—gaming headsets are great for co-ordinating with teammates, but they aren't exactly the kind of thing you'd carry with you walking out the door.

That's why I've been enjoying my time with Logitech's new G433 gaming headset, which can pull double duty as your desktop communicator and your commuter cans. With a detachable cable, you can easily swap from the USB digital soundcard dongle at your desk to a commuter-friendly cord with inline media controls.

Internals-wise, it has all the hallmarks of a solid headset—7.1 surround sound, 40mm drivers, and a detachable boom mic. But on the outside, things get interesting. Instead of big leathery cans housed in a plastic monstrosity, the G433 is sleek and stylish, lined with a hydrophobic sport-mesh fabric. This makes the G433 feel closer to a pair of Beats—the kind of headphones that don't make you feel stupid in public—but with good sound and communication ability.

$100, http://gaming.logitech.com

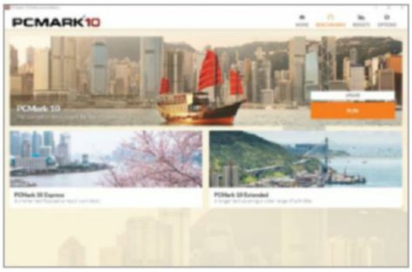
PCMARK 10

Benchmarking gaming PCs is easy; more serious desktops less so; which is why there's a market for Futuremark's benchmarking tools. PCMark models modern workloads to produce an index that allows systems to be quickly compared. PCMark 10 is the latest iteration, updated for Windows 10, and quicker to run than its predecessor. It'll soon be making its way into our benchmark tables, replacing PCMark 8 when we're happy with the numbers it produces.

The main interface has been updated to more closely resemble that used by 3DMark and VRMark, and offers a single-button execution, which makes our lives easier. The suite itself replicates web browsing, application work, and video conferencing. The extended benchmark includes gaming tests from 3DMark, which shows how we're expecting more and more from our PCs.

Of the four versions available, only the Advanced ($30) and Basic (free) editions are of interest to home users. If you just want to see how your own machine fares, the latter enables you to compare your system against the scores you'll see from us. Advanced has a few more tests—useful if you're a system builder, and want to push your machines.

$30, www.futuremark.com



GEEK TESTED & APPROVED

4K 30W
00:05
1H55
GoPro

Go Pro Hero 5 Black

I'VE BEEN TRYING for nigh on a year, working various PRs and contacts, until at long last I managed to get perhaps the best action camera around into the mag.

There's a term we use in the industry, a feeling that we associate with a good product: "It's just a nice thing." It's the highest praise imaginable. Like a flagship smartphone, a curved monitor, a well-designed car, the Go Pro Hero 5 Black is one of those things.

Whether it's the cageless design, the waterproofing to 33 feet, the optical image stabilization, the ability to video 120fps 1080p and 4K at 30, take RAW photos, or even the included telemetry you can bake into your clips, there's just something special about this camera that sets it apart from the competition, and justifies that high price tag.

I had the pleasure of taking this on a mountain bike trip to New Zealand recently, and was blown away by how well it performed. Whether that was in the mud-drenched trails surrounding Dunedin, or the sun-dried dust tracks in the north island, it was stunning. For most of my testing, I used one of Go Pro's chest harnesses, and forgot it was there the majority of the time.

There's no doubt it's a pricey camera, and something that fills a niche, but the versatility of mounts and uses keeps us coming back for more. It's perfect for a wannabe extreme sport athlete, taking the kids on holiday, or even everyday vlogging. Criticisms, aside from the price? Well, it still has that fish-eye lens, the mounts are also fairly expensive, and wind noise is still tricky in places. Check out some test footage I shot here: http://bit.ly/mpcgopro5vid. **–ZS**

$400, www.gopro.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Serving Home
> Doubling Up on GPUs
> Recommending Routers

Serve You Right

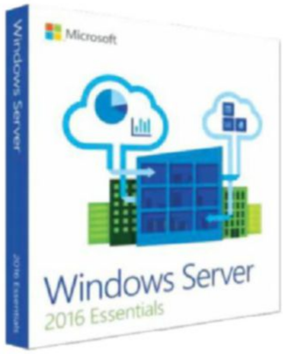
I love the magazine and have been a subscriber for over 12 years now. After reading an article in your magazine many years ago about the HP Mediasmart Server, I was hooked. That server was damaged in a lightning strike, so I decided to build my own, and am very happy with the outcome. The server has saved my bacon several times, mostly noted when my wife went back to school for her BSN, and the hard drive in her computer failed. The system was restored in 90 minutes, with no loss of any document. It is also helpful when watching my grandchildren and nap time comes around—I am able to stream classical music through our smart TV.

I wait patiently every month for my copy of *Maximum PC* to arrive, always looking for articles on home servers. Every time I see an article, the build always includes a Linux distro as the operating system. Guys, how about showing us peeps running the many versions of Windows Server some love? How about some tips and tricks on the server side? Thanks for taking the time to read my letter, and have a great day!

–Raymond G Fletcher

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: You'll encounter two types of people when talking about Windows Home Server (WHS): Those who have used it are very positive about their experiences, but everybody else (the vast majority, in fact) has no idea what you're talking about. Don't get me wrong, WHS was really good, but it was a niche product. In fact, it was probably way ahead of its time, as we can see a much greater need for WHS today than when it was first released 10 years ago.

However, the fact that it is no longer supported (as of April 2016, it is officially "end of life") means that there is a limited market for any content on it. And because it is a fairly straightforward thing to use (definitely one of its strengths), there aren't many tips and tricks out there. One thing to bear in mind is that a lot of what we're trying to do with our Linux tutorials is emulate some of the greatness that you already have from your versatile Home Server. So even though it isn't supported anymore, it's worth keeping going as long as you can, because it's a great operating system.



At $560, the newer Windows Server 2016 Essentials isn't a great deal for the home.

Insecurity of Things

Am I the only one who thinks the Internet of Things is a terrible idea? We can't secure the Internet, and now you want to put my appliances, thermostat, and home security system on it? No thanks. **–Alain DeWitt**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: Speaking to the rest of the team, there's a general agreement with what you're saying. There are plenty of problems that we need to sort out before we make things worse by hooking everything to the Internet. At least the security industry has spotted the potential problems, and is on the case to make things secure, but whether anyone is listening or just getting carried away by the possibilities is another matter. For now, the onus is on us early adopters and tech-savvy users to sort things out, and for us, at least, the benefits don't really weigh up well against the amount of effort needed.

Double Indemnity

I'm looking to buy/build a new gaming PC. I want to get a rig that will perform well running games in 4K, and would like your advice. From the reviews I've seen so far, the Nvidia GeForce GTX 1080 Ti is the top GPU to handle 4K gaming. My query is how would twin 1070s in SLI compare at 4K performance to the 1080 Ti?

–Doug Forsyth

REVIEWS EDITOR ZAK STOREY RESPONDS: The biggest problem with SLI is SLI profiles. Depending on the game and dev team, you can

↘ submit your questions to: comments@maximumpc.com get performance increases of near 100 percent or 0 percent. *Total War: Attila* is a fine example of the latter, because there is no SLI profile at all, rendering that second card nothing more than a power-drawing paperweight. Well-established games, on the other hand, are generally fine, but it may take two to three weeks after release for SLI profiles to become available (included in driver updates). Additionally, don't expect driver optimizations or SLI profiles at all for any title sponsored by AMD, because Nvidia tends not to support them until three to four months after the initial launch. Petty, I know, but that's how the world works.

Generally speaking, we always advocate a single, more powerful card over two in SLI. That way, you avoid the profile issue, draw less juice from the wall, and just have the raw grunt to play games at those kinda resolutions with ease. It definitely looks cool, but aside from that, there's no advantage to going SLI, unless you're already at the bleeding edge of tech (i.e. running two flagship cards).

Spell It Out

I am 79 years old, and my technology experience started in the vacuum tube era. Over the years, I have seen acronyms used and reused, which makes things a little confusing.

I've been reading the June issue of *Maximum PC*—or maybe it's *MPC*.

Pages 20 and 21 use the acronyms TN, IPS, and VA, and never spell out what they are. They are not in the acronyms list, and I have no idea what they are. Makes for a very useless article.

Page 71 uses the term "SSH logins." Not in the acronyms list, so what the hell is it referring to?

Acronyms are fine as long as they are spelled out when first used in an article. I generally enjoy your magazine, but this kind of crap has to go.

–Victor Kroenke

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: Criticism duly noted. We'll make a more concerted effort to spell these things out going forward—although, in our defense, expanding some things doesn't always make it clearer. As a case in point: TN stands for Twisted Nematic, IPS for In-Plane Switching, and VA for Vertical Alignment. These are all LCD panel technologies, although knowing what the acronyms stand for isn't particularly useful on its own. As for SSH, that stands for Secure SHell, and it's used for remote logins.

Route to Success

I have been a loyal reader of your magazine ever since it was called *boot*. Matter of fact, I still have the very first and last copies of *boot* magazine, July/August 1998, Vol. 3, No. 7, before the change to *Maximum PC*. Anyway, I was reading the "Letters" section in the latest issue of June 2017 (Vol. 22, No. 7), and wanted to comment regarding the "A Route to Love" letter. The reader suggested doing a router roundup of current makes and models, which would be a fantastic idea, but I might also have one for the DIY readers. What about doing an article on how to use a spare (old) PC to build your own pfSense router?

–Brian Waterbury

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: We will be visiting a router roundup soon, but in the meantime, we love the idea of building your own router, or turning an old machine into one, so watch this space. On that note, we did show you how to secure your network using IPFire in the May 2017 issue (Vol. 22, No. 6), and how to turn a Raspberry Pi into a firewall, back in the April issue (Vol. 22, No. 5), so it is definitely an area we cover.

Under Control

Maximum PC June 2017, page 74, section 5: Who is the manufacturer and what is the model of that fan controller? **–Richard**

REVIEWS EDITOR ZAK STOREY RESPONDS: The fan controller in that build is baked into the NZXT Manta itself. It's a fairly low-spec piece of gear, based on the original NZXT Grid (not the V2 version). Unfortunately, you can't buy it anymore, as it was replaced by the Grid V2, which connects via a USB header to the motherboard, instead of a single PWM header. This is to integrate into NZXT's CAM software better, allowing for fully configurable fan curve profiles for each fan—it's also a little pricey, at $31.

That said, Phanteks sells a far less complicated version (plugging directly into a single PWM header on the motherboard), more akin to the fan controller used in the build in question. You'll find the Phanteks PH-PWHUB_01 PWM Fan Hub on the likes of Newegg for a shade over $18.

A New CPU?

I recently saw something about a Core i9 processor. I looked it up, and was blown away by the specs. Ten physical cores! And Hyper-Threading! Did I miss the article, or is it upcoming? I don't remember seeing the processor mentioned in the magazine. Secondly, can we expect to see this badass processor in the next Dream Machine? **–Kurt Colbourne**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: There are plenty of interesting chips in the Core i9 line-up, including the highest offering, which boasts 18 physical cores (with Hyper-Threading). We've actually had 10-core, 20-thread mainstream processors for just over a year now, in the form of the Core i7-6950X. There is a new Core i9 processor spin of this chip, though: the Core i9-7900X X-series processor, which runs at a slightly faster 3.3GHz, as opposed to the 3GHz of the 6950X. You'll find the full review of this new Core i9 chip on page 78 this month. As for the Dream Machine, you'll have to wait until next issue to see what it's built around. Not long to wait, then....

[NOW ONLINE]

HOW THE $500 XBOX ONE X COMPARES TO A PC

In a livestream, Microsoft went over some of the advanced capabilities of the Xbox One X, including Dolby Atmos audio support and HDR video. The Xbox One X will supersample existing Xbox One games, which is useful if you don't have a 4K TV. It will run them at 4K resolution, downsampling to a 1080p resolution for a sharper picture. Microsoft also announced that the Xbox One X is its smallest Xbox console ever, which makes for a pretty damn compact box if it's smaller than the Xbox One S.
Read the full article: http://bit.ly/2ssp49l

Future

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THE BUILDS

BUDGET

MID-RANGE

INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Evolv ITX	$70
PSU	EVGA 450B Bronze	$40
Mobo	MSI B250I PRO Mini ITX	$90
CPU	Intel Pentium G4600 **NEW**	$87
GPU	Gigabyte GeForce GTX 1050 Ti 4GB	$140
RAM	8GB (2x 4GB) Ballistix Sport LT DDR4 2400 **NEW**	$60
SSD	Kingston SSDNow UV400 120GB SATA 2.5-inch	$57
HDD	1TB Seagate BarraCuda E.2 7,200rpm **NEW**	$45
OS	Ubuntu Desktop Linux 16.04 LTS 64-bit	$16

Approximate Price: $605

DARN PRICE HIKES ruining our day, and our builds. This system represents what we think qualifies as a semi-decent base and upgrade path for anyone looking to join the PC enthusiast community. With flash SSD, 8GB of memory, and a relatively substantial CPU and GPU combo, it's designed to hit that price-to-performance mark on the head, for around $600. It's not perfect, but for the price, it's hard to beat. This month saw some serious price hikes regarding last issue's CPU, the Pentium G4560, placing it higher than the more powerful G4600. So, we decided to ditch the now $110 G4560 in favor of the G4600, which comes in well below that price, with a substantial increase to core clocks. The one thing we would change here is the GPU, but graphics cards are in an odd place right now. Thanks to the Ethereum boom, the price of most mid-range cards is skyrocketing, because dedicated ASIC cards can't mine the stuff just yet.

INGREDIENTS

PART		PRICE
Case	NZXT S340 Elite	$100
PSU	EVGA SuperNOVA 550 G2	$90
Mobo	MSI X370 SLI PLUS	$140
CPU	AMD Ryzen 5 1400	$170
Cooler	Corsair H100i v2 + bracket	$105 + $5
GPU	Gigabyte GeForce GTX 1070 Extreme Gaming 8GB **NEW**	$460
RAM	16GB (2x 8GB) G.Skill V Series DDR4 2666	$120
SSD	250GB Samsung 960 Evo M.2 PCIe NVMe SSD	$130
HDD	Western Digital Blue Series 1TB 7,200rpm	$50
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $1,470

NOW IS NOT A GOOD TIME to buy a graphics card. Two types of people are controlling the market: Ethereum miners, scooping up every card possible to cash in on the new cryptocurrency, and price scalpers, trying to cash in on the aforementioned miners. This means that the price of a GTX 1070 has gone from $350 last month to $460 this issue. We've also seen an increase in the price of memory yet again, going up by another $10. That's the last of the bad news, however, as everything else has stayed the same—except the 250GB Samsung 960 Evo, which has fallen by $30, making it one of the best-value M.2 PCIe SSDs out there. In fact, if you're in the market for an SSD, scrap any thoughts of grabbing a standard 2.5-inch, and invest in this instead. It feels odd to say, but right now, we wouldn't recommend you build this rig, or if you do, forsake the graphics card, until this new wave of cryptocurrency dies down, and the manufacturers pick up the slack in availability.

TURBO

THANK THE DEAR AND FLUFFY LORD (*Serenity* reference) for PNY. Without it, that $10 price hike on the GTX 1080 Ti could be far worse. Three AIB designs are available for around $700, and although that still sounds terrible, it's a far cry from the $100 price hike seen across the GTX 1070 series. That said, we took the opportunity to tweak a few things, in an attempt to reduce our overall costs.

We opted for the Ryzen 7 1700 this issue, for its super-low TDP. Coming in at 65W versus the 1800X's 95W, the power savings are substantial. Couple that with the fact that you can throw a quick and easy overclock at it, and achieve the same if not better performance across the board, and it quickly becomes the best processor to buy out of the series for anyone looking to build a professional grade workstation.

That aside, everything else has stayed relatively unchanged. 32GB of DDR4 2666 is a solid choice for this system. And although Ryzen's memory niggles are slowly edging their way out of the platform, we wouldn't recommend anything above 3,000MT/s, unless you're happy to tinker away with settings to get it performing just right.

Storage also remains the same, with a slight $13 increase to the 1TB 960 Pro, pushing it back up to $630. However, the 4TB WD Black HDD has stayed at the same price—a comfortable $200.

For more of our component recommendations,
visit www.maximumpc.com/best-of-the-best

INGREDIENTS

PART			PRICE
Case	Phanteks Eclipse P400S Tempered Glass Silent Edition		$80
PSU	Corsair RM750X Modular Gold		$100
Mobo	MSI X370 Gaming Pro Carbon		$180
CPU	AMD Ryzen 7 1700	**NEW**	$310
Cooler	NZXT Kraken X62 280mm AIO		$160
GPU	PNY GeForce GTX 1080 Ti FE	**NEW**	$700
RAM	32GB (2x 16GB) Corsair Vengeance LED DDR4 2666		$255
SSD	1TB Samsung 960 Pro M.2 NVMe SSD		$630
HDD	4TB WD Black 7,200rpm		$200
OS	Windows 10 Home 64-bit OEM		$100

Approximate Price: $2,715

UPGRADE OF THE MONTH

AMD Ryzen 7 1700
AMD
RYZEN

RYZEN 7 1700

Here we are back with a gem of a processor once more. AMD's Ryzen has transformed the marketplace. We've not seen competition like this since the early 2000s—and that's no bad thing. Intel's response with the X299 platform, including its four-core i5 processors on the 2066 socket, seems to be a knee-jerk reaction, and the price drops, although impressive, still lack substance compared to the forthcoming Threadripper, and even the current generation of Ryzen chips. The 1700 is still the best-value chip right now, especially if you're looking at any serious workstation application.

$310, www.amd.com

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